ATELIER MONITORING AND EVALUATION FRAMEWORK

Deliverable 9.1: Repository of definitions of terms, key characteristics archetypes, and a set of KPIs

WP9, Task 9.1

31/10/2020 (M12)

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[1] PU = Public

PP = Restricted to other programme participants (including the Commission Services)

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Document History

Project Acronym	ATELIER	
Project Title	AmsTErdam and BiLbao cItizen drivEn smaRt cities	
Project Coordinator	Frans Verspeek ATELIER.EU@amsterdam.nl City of Amsterdam	
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Deliverable No.	D9.1 Repository of definitions of terms, key characteristics archetypes, and a set of KPIs	
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Work Package Lead	**PSI**	
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DoA	During the proposal preparation stage, partners in charge of the PED implementations in Bilbao and Amsterdam have built up a first draft of an Extended List of Indicators (ELIs), which defines the main categories of the indicators, their spatial resolution, linkages to specific WPs, definition and units. 8 categories with around 90 indicators are covered in monitoring, including general characteristics (4 indicators), economic (13), energy (25), environment (15), social (12), mobility (7), spatial (5), and	

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	communication (9). This first draft, together with impact indicators (from section 2), will be reviewed, checked and detailed (i.e. how, when, where these indicators will be monitored), and necessary terminologies will be defined during the first 6 months of the project, together with LHs and local stakeholders and citizens in the communities. In a second phase (M7-M12), we will identify jointly with WP 10 and 8 a more concise list of KPIs and ensure a regular and standardized internal data flow. The KPIs will be well-aligned with already available standards and frameworks1. The final list of KPIs will be in conformity with SCIS, ESPRESSO and CITYkeys. Archetypes will be defined, and they will be the basis of impact assessment and will be essential for replication of PEDs from the LHs to the FCs and other EU cities. An archetype stands for a typical compound entity that shares similar properties and characteristics, such as energy demand pattern, composition of population by different criteria, density and other context-related factors (e.g. weather, available resources, etc.). The spatial resolution of archetype should be flexible enough in a sense that it can be a cluster of buildings and infrastructures, or an individual building or infrastructure. Defining archetypes will help city planners and stakeholders to better understand any PED as a general system, as well as the key factors that will affect the impacts of certain measures, rather than solely being limited to the specific context of Lighthouse cities

Date	Version	Author	Comment
17/10/2020	1	DEU	First draft of deliverable
30/10/2020	2	DEU	Official document according to suggestions of internal reviewers (COA and CAR)
30/07/2021	3	DEU	Revised deliverable after comments of the external reviewers

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Abbreviations and Acronyms

Acronym	Description
BEMS	Building Energy Management System
DH	District Heating
DHW	Domestic Hot Water
DMP	Data Management Plan
DPIAO	Data Protection Impact Assessment Officer
DSM	Demand Side Management
DSO	Distribution System Operator
EC	European Commission
EE	Energy Efficiency
EMS	Energy Management System
ESS	Energy Storage System
EV	Electric Vehicle
FC	Fellow City
GFA	Gross Floor Area
ICT	Information and Communication Technology
GHG	Green House Gases
KPI	Key Performance Indicator
LCA	Life Cycle Assessment
LHC	Lighthouse City
M&E	Monitoring and Evaluation

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PED	Positive Energy District
PV	Photovoltaic
QoL	Quality of Life
ROI	Return on Investment
RES	Renewable Energy Sources
SCC	Smart Cities and Communities
SCC TG	Smart Cities and Communities Task Group
SCIS	Smart Cities and Communities Information System
V2G	Vehicle to Grid
WPL	Work Package Leader
WP	Work Package

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Executive Summary

ATELIER incorporates multiple solutions that will accelerate the energy transition in Amsterdam and Bilbao. The ATELIER Positive Energy Districts (PEDs) are designed as urban laboratories where innovative approaches and structural models will be deployed and validated in a continuous and dynamic approach. The methodological framework for monitoring and evaluation (M&E) that we present in this document should allow for adaptation resulting from the experience in ATELIER itself and the emerging best practices in other projects.

This document defines the main M&E principles that consider monitoring as an instrument for evaluation. According to the M&E principles, the process is transparent to the project partners that are involved in monitoring and to a broader audience connected to the process; allows a shared ownership across the project partners; endorses additionality with respect to a baseline scenario, etc. ATELIER project undertakes evaluation as an internal feedback mechanism where we produce valuable interim conclusions and recommendations related to project implementation. In this overarching document we define:

- System boundaries and temporal scales,
- Baseline approaches and expected impacts, targets, and benchmarks,
- The governance model that allows the implementation of shared ownership,
- The main evaluation domains and first list of Key Performance Indicators (KPIs), and
- Tools to be shared and next steps.

Based on the state of the art of Smart Cities' Monitoring and Evaluation, the requirements from the Smart City Information System, and experience gained by the interchange with other lighthouse projects and the Smart Cities and Communities (SCC) partnership, we propose an initial set of M&E indicators. Based on the actual list of indicators proposed (see below), and available as KPI repository (Annex 1), we will pursue a continuous iteration process with the specialists of the different areas (energy, mobility, digitalization, social awareness, etc.) both in Bilbao and Amsterdam.

Table 1: Key Performance Indicators of ATELIER project (names, units and definitions)

ENERGY performance related KPIs		
Name	**Unit**	**Description**
Energy Use	MWh	The KPI energy use tracks the final net energy consumption in terms of primary energy within the territory boundary of the PED by the end users or systems to provide and operate the different energy services.
Electricity use	MWh	The KPI electricity use tracks the final electricity use within the territory boundary of the PED by

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		the end users or systems to provide and operate the different electricity-based services.
Thermal energy need	MWh	The KPI thermal energy need tracks the final net thermal energy needs for space heating, space cooling and hot water within the territory boundary of the PED by the end users or systems to provide and operate the different heat services.
Energy savings	MWh	This KPI determines the reduction of the final net energy use of the PED, calculated in terms of primary energy, to reach the same services (e.g. comfort levels) after the interventions, taking as reference the energy use from the baseline.
Renewable energy	MWh	This KPI monitors the total renewable energy generated within the boundaries of the PED. It accounts for energy from sources that are not depleted by extractions, such as solar energy (thermal and photovoltaic), wind, water power, and renewed biomass.
Renewable electricity production	MWh	This KPI monitors the amount of electrical energy derived from renewable sources within the boundaries of the PED.
Renewable thermal energy production	MWh	This KPI monitors the amount of thermal energy derived from renewable sources within the boundaries of the PED.
Exported energy	MWh % hour	The exported energy KPI tracks the surplus renewable energy delivered outside the PED over a period of time. It combines both thermal and electrical energy by comparing the final

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		energy needs and renewable energy generation.
Exported electricity	MWh % hour	The KPI exported electricity monitors the surplus electricity delivered outside the PED over a period of time determined, by comparing the final electricity use and the locally produced renewable electricity production
Exported thermal energy	MWh % hour	he KPI exported thermal energy monitors the surplus renewable thermal energy delivered outside the PED over a period of time determined, by comparing the thermal energy needs and the renewable thermal energy production.
Energy exported outside the PED at peak time	MJ % hour	The KPI energy exported out of the PED at peak time, calculates the net surplus renewable energy delivered outside the PED boundary during the daily peak hours.
Percentage of peak load reduction	%	Percentage of peak load reduction is calculated by comparing the peak energy demand before the aggregator implementation (baseline) with the peak demand after the aggregator implementation (per final consumer, per feeder, per network).
Energy storage capacity installed	MWh	This KPI measures the local storage capacity for energy balancing within the PEDs. The KPI is calculated as the sum of the installed storage capacity, which is an important parameter in relation to the energy load and production.

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ENVIRONMENTAL performance related KPIs		
Name	**Unit**	**Description**
Energy-related greenhouse gas emissions	kton CO2 eq/y	Greenhouse gases emissions related to operational energy consumption within the PED, It is calculated by multiplying the final energy consumption for each conversion factor per energy carrier
Energy-related greenhouse gas reduction	kton CO2 eq/y	The greenhouse gas emissions reduction assesses the greenhouse gas emissions savings resulting from interventions in PED
Life cycle greenhouse gas emissions	kton CO2 eq	Life cycle infrared radiative forcing increase due to the emissions of greenhouse gases caused by PED due to the consumption of materials and provision of services
Life cycle primary energy demand (non-renewable)	kWh oil eq	Life cycle non-renewable primary energy demand due to consumption of products and service provided in the PED
Total environmental footprint	points	Life cycle based holistic assessment of environmental impacts on ecosystem, human health and resources scored on various life cycle environmental impacts (greenhouse gas emissions, ozone layer depletion, human toxicity, fine particulate matter, ionizing radiation, etc.).
Particulate matter emissions (PM 2.5) reduction	kg/y	Particulate matter emission reduction based on the calculation considering vehicle types and fuel properties before and after project interventions
Nitrogen oxides emissions (NOx) reduction	kg/y	Nitrogen oxides (NOx) emission reduction based on the calculation considering vehicle types and fuel properties before and after project interventions
Water consumption reduction	m3/y	Water consumption can be reduced due to water conservation measures (e.g. vacuum toilet). This KPI will measure the reduced water consumption.

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Received noise by building users	n.a.	Noise is an important indicator related to human health and the quality of life.
Outdoor noise	dB	Noise is an important indicator related to human health and the quality of life. Implementation of heat pumps and electric vehicles will have influence on the onsite noise levels, which will influence the experience of the residents and users in the PEDs.
Indoor humidity	%	This indicator will be measured onsite at hourly-timestep. Indoor humidity is a key indicator that reflects the comfort of residents and building users
Indoor Temperature	ºC	This indicator will be measured onsite at hourly-timestep. It is important to measure it in relation with how residents and building users feel comfortable
Outdoor Temperature	ºC	Outdoor temperature will be measured onsite at hourly-timestep. It is related to the indoor temperature and with the effect of possible (undesirable) hot islands

ECONOMY performance related KPIs		
Name	**Unit**	**Description**
Simple Payback period	year	The payback period is the time it takes to cover investment costs. It can be calculated from the number of years elapsed between the initial investment and the time at which cumulative savings offset the investment.
Total Investment	€/m2 or €/kW	An investment is defined as an asset or item that is purchased or implemented with the aim to generate payments or savings over time. The investment in a newly constructed system is defined as cumulated payments until the initial operation of the system

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Total annual costs	€/year	The total annual costs are defined as the sum of capital-related annual costs (e.g. interests and repairs caused by the investment), requirement-related costs (e.g. power costs), operation related costs (e.g. costs of using the installation, i.e. maintenance) and other costs (e.g. insurance).
Average CO2 abatement costs	€/ton of CO2-eq/y	The specific KPI estimates the costs in euros per ton of CO2 saved per year. This KPI can be estimated by capitalizing on information already available in other KPIs: carbon dioxide emission reduction and total annual costs.
Local energy resources traded locally	%	The amount of local RES traded in relation to the total amount produced is an indication of the attractiveness of the PED scheme. This KPIs assumes that the local energy trading will provide a financial incentive to local RES because local buyers will pay a surplus.
Consumer engagement	Likert	This KPI assesses the level of interest across all inhabitants in a PED in the options for active involvement in the energy supply and demand. This included energy and flexibility trading, as well as individual demand-side management.

ELECTROMOBILITY performance related KPIs		
Name	**Unit**	**Description**
Annual energy demand by charging infrastructure	kWh/month; kWh/year/charging station; Annual kWh	This KPI measures the total energy consumption of EVs in the PED. This is an important parameter since it will presumably have an impact into the smart grid operation.

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Shift from fossil-fuel vehicles to electric mobility	km/vehicle/y # of trips/vehicle/y km/year # of trips/year	Relative modal shift from fossil-fuel vehicles to electric mobility in the PED area
Contribution of V2G to the grid	kWh/y	This indicator measures the total amount of energy (kWh) that is charged from Vehicle to Grid (V2G). This technological solution is currently widely explored to benefit both the EV charging demands as well as the flexibility of local energy systems.
Share of EVs' energy demand covered by local RES	%	Relative share of EV demand covered by local RES in the PED energy system

CITIZEN ENGAGEMENT AND PARTICIPATION performance related KPIs		
Name	**Unit**	**Description**
Quality of Life	Likert	Improvement of the quality of life for the PED inhabitants
Energy citizenship	Likert	Progress towards energy citizenship
Lifestyles	Likert	Impact on habits and lifestyle towards sustainability
Pulse	Likert	Feeling the pulse - monitoring citizen engagement

UPSCALING, REPLICATION and GOVERNANCE performance related KPIs		
Name	**Unit**	**Description**
Suitability of Fellow Cities	Likert	Suitability of the locations in Fellow Cities for PEDs

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Progress of Fellow Cities	Likert	Progress of Fellow Cities in the replicability of PED implementation
Progress in Upscaling	Likert	Progress at the PED demonstrations towards upscaling
Progress in policy making	Likert	Progress in enabling policy, legal and planning framework in Lighthouse cities (LHC) and Fellow Cities (FC)

KNOWLEDGE GENERATION AND SHARING performance related KPIs		
Name	**Unit**	**Description**
Number of scientific publications	#	Number of scientific publications (peer reviewed) is a simple and straightforward indicator about the research carried out in ATELIER
Public papers and conference contributions	#	Communication and dissemination instruments include publishing news, press releases, opinion papers, newsletters, conference papers, etc.
Info Packages on PED smart solutions	#	They include different sorts of materials: Best practice booklets for politicians, industry, NGOs, etc. that will be specific to ATELIER solutions and will be tailored to different audiences.
Seminars, workshops and events	#	Participation in seminars, workshops and events either for knowledge sharing within ATELIER partners and close-related stakeholders or in broader international events will contribute to knowledge generation and sharing

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1. Introduction to the report

ATELIER will monitor and evaluate the performance and impacts of the PED demonstrations, as well as of the smart solutions that are included in the PED design. Also, the PED concept will be validated in the Lighthouse cities. This will provide valuable feedback to the local innovation ecosystem that was involved in the implementation of the smart urban solutions, and will deliver input to the Bold City Vision for 2050, further scaling up in the Lighthouses, and replication plans of the Fellow cities. In addition, the progress of the ATELIER project towards its objectives and targets as a whole will be monitored and evaluated. The monitoring and evaluation (M&E) activities will be coordinated by ATELIER work package 9, and developed and implemented in close cooperation with the project partners.

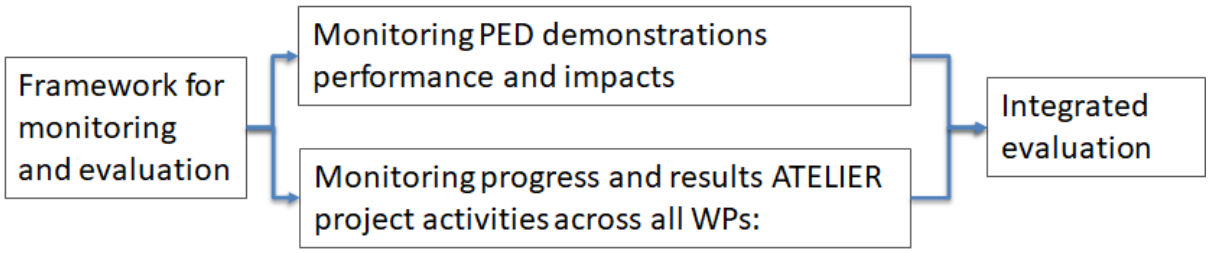

Figure 1. Methodological framework for Monitoring and Evaluation

This report

This report informs about the first activities and achievements scoping on the project's M&E. As such, it represents the first out of the six planned deliverables related to M&E:

1. **Repository of definitions of terms, key characteristics archetypes, and a set of KPIs (this report)**
2. Indicator database with input and output data interfaces defined across other relevant activities of the project, as well as to SCIS reporting system
3. Web-based online indicator observatory for the M&E of ATELIER
4. Report on impact assessment report for the operational PED measures
5. Impact assessment report and/or tool development on broader impacts at city scale
6. Internal and external evaluation reports (annual)

This public report presents the M&E principles and approach, as well as an initial list of KPIs. It provides the basis for continued discussions with project partners and involved stakeholders on the evaluation approach, the choice of KPIs and the corresponding monitoring approach. M&E will support the project partners getting track and coordinating the project activities and their results.

Drafting process

Core partners leading the full process have been PSI, AUAS and DEUSTO. The deliberation process was performed with ATELIER developers (IBERDROLA, TELUR and SPECTRAL) during the first phase; that is, the development of the bottom-up approach (see section 3.1).

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During the second phase (top-down approach) we have been in contact with other EU smart city projects and more specifically with the partners in charge of developing the M&E methodology. We have also contacted the partners in charge of estimating the overall energy balances and BEST tables of PEDs in Amsterdam (COA) and Bilbao (EVE), as a possible entrance point for the definition of the baseline approach (see section 3.7). Other important iterations include the seminar on 'ATELIER Modelling and impact assessment' proposed within the ATELIER partners and the regular meetings with the SCC1 Monitoring & Evaluation Task group.

Living document

This monitoring and evaluation framework presented in the report will be further discussed and developed, in consultation with the project partners, and in exchange with other projects. This is, therefore, a living document, and updates will be published, up to the start of the monitoring period. In the next public report, the updated list of KPIs will be reported as well as the finalised M&E framework.

Guide to the reader

In chapter 2 we introduce our principles and approach to the monitoring and evaluation of the ATELIER projects and the PED demonstrations. We will apply a combination of performance-based monitoring and reflexive evaluation. This is the basis for our approach in selecting KPIs across all evaluation domains (chapter 3). In chapter 4 we summarise the list of KPIs.

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2. ATELIER's approach to monitoring and evaluation of the project and PED demonstrations

2.1 Approach to M&E

The ATELIER project will be evaluated annually on the basis of the monitoring results and the impact assessments carried out under the project's M&E activities, as well as the assessment of progress of the project itself. When possible, the interim evaluations will result in internal corrective actions in case the targets are not met by the actual performance. The evaluation will also produce lessons learned and recommendations on PED development, replication and exploitation.

The scope of the evaluation is the full ATELIER project, including both the PED demonstrations as well as all other related aspects (as defining the City Vision, stablishing the Innovation Ateliers (set of seminars, workshops and co-design sessions organised by the ATELIER partners), facilitating the replicability, fostering citizen engagement, the collaboration with other similar projects, and the dissemination and exploitation of the project results).

The EC provides the following technical definitions of M&E:

- **Monitoring** uses systematic collection of data on specified indicators to provide management and to also provide the main stakeholders of an ongoing intervention with indications of the extent of progress and achievement of objectives and progress in the use of allocated funds [1].
- **Evaluation** is a systematic and objective assessment of ongoing or completed interventions (actions/policies), their design, implementation and results according to the following criteria: relevance, effectiveness, efficiency, sustainability, impact, coherence and EU added-value. From the perspective of drawing conclusions and recommendations, this definition is complemented as follows: Evaluation provides the information that is required to draw validated conclusions and recommendations from the project, as defined by the objectives and scope of ATELIER.

ATELIER has specifically addressed monitoring and evaluation in the project set-up. ATELIER's M&E activities have multiple objectives as they aim at providing the required data for progress and performance reporting of the PED-related measures performed in ATELIER, but it also will profile itself as supporter to the implementation of specific activities and interventions of the project in order to evaluate the effectiveness and status goal achievement, as well as the impacts at broader scales.

As such, M&E helps the project by evaluating how the PEDs in general and specific measures perform and if the envisaged targets are reached. Therefore, M&E aims at providing regular feedback to the other project activities in order to inform, discuss and evaluate the performance indicators jointly. In addition, M&E enables the benchmark with other PED projects and pursues an active exchange with them on lessons learned and methods applied. Finally, the activities scheduled under the M&E umbrella serve the formal reporting of the monitored data to the SCIS platform and for preparing the PED performance data for dissemination to the Commission and for a broader audience.

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2.2 Main principles to the M&E framework

We have started the design of the M&E framework of ATELIER by setting our main principles to which the M&E framework should adhere.

Monitoring is instrumental to evaluation. The evaluation framework is leading in the design of the monitoring framework. On the one hand, the evaluation should be based on the monitoring results; on the other, monitoring has no value if the results are not used in evaluation. Therefore, monitoring is instrumental to evaluation. In respect to the selection of KPIs, it should be clear which evaluation question the KPI contributes to.

Transparency of the M&E framework. The M&E framework should be transparent to 1) the project partners that are involved in monitoring and 2) the audience for recommendations resulting from the (interim) evaluations. The same applies for the external target groups for the conclusions and recommendations of M&E. The project evaluation should address the full spectrum of the project's objectives and targets. In combination with the complexities of PED technical, economic and social systems, there is a risk that M&E frameworks become very complex. This implies the right balance needs to be found between the match with the project's objectives and targets on the one hand, and the transparency on the other.

Shared ownership across the project. M&E is not just the responsibility of the partners involved in M&E work package. It is important that the M&E process is shared collectively among all project partners. To this purpose, M&E will involve the partners of the different steps of the process. For each KPI, a partner will be appointed as owner of the KPI.

Additionality to a baseline scenario that would have happened anyway. 'Additionality' refers to the impacts caused by actions beyond what would have occurred in the absence of the policy program, subsidy, or other interventions. What would happen in the area without the project and without the implementation of the PED, and without the ATELIER projects? Without assessing additionality at all levels in ATELIER, it is impossible to conclude on the actual impact of the project and the PED solutions, and to recommend to city planners on the advantages of PEDs in relation to other policy measures.

This is specifically relevant for PEDs because they are not a new measure; they are to a large extent based on common practices often already regulated, complemented with a set of new innovations. For example, the Amsterdam PED demo comprises mainly green field building developments. These are already subject to regulation of energy performance, that would bring new buildings to near-zero energy. Monitoring and evaluation should show that the performance and impact of the PED goes beyond this baseline, and that this additional impact can be directly attributed to the specific PED innovations.

Evaluation as an internal feed-back mechanism. Evaluation is not an afterthought of a project, but needs to start at an earlier stage in the form of interim project evaluations. This will produce valuable interim conclusions and recommendations on the implementation approaches through the project. Also, it will allow finetuning and adaptation of the M&E approaches improving the quality of subsequent evaluations.

M&E as a process, not a fixed system. We will set up the structure of the M&E framework in the initial phase of the project. Also, some part of the monitoring frameworks and the set of KPIs need to be decided early allowing the installation of the corresponding metering.

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However, we note that monitoring and evaluation is a dynamic process. During the project the framework should allow for adaptation resulting from the experience in ATELIER itself and the emerging best practices in other projects. It makes no sense to stick to monitoring a specific KPI as halfway during the project it becomes clear it has no value.

Building on the M&E experience of other smart city and SCC projects. Since the start of the SCC programme, a wealth of experience has been gained with monitoring and evaluation. ATELIER will incorporate this experience into our own framework. Moreover, we aim to harmonise the M&E framework with other SCC projects that deal with PEDs. We recommend a portfolio approach to the evaluation of the all PED SCC projects that are ongoing currently. This will require the following steps:

- Harmonisation of the M&E frameworks, including the set of KPIs.
- Sharing of the detailed design of PEDs and the underlying interventions.
- Sharing of the results of monitoring and impact assessment at an early stage.
- Collaborative effort to establish a common evaluation framework for the portfolio.
- Common publication on the results of the portfolio.

The SCC Lighthouse Task Group on Monitoring and Evaluation, which will be supported by the SCALE project, could take this up, to be supported by ATELIER and other SCC projects.

2.3 Baseline approach

The impact of PEDs cannot be directly measured in terms of energy (CO2, or any other variable) savings, because savings represent the absence of energy consumption or demand. Instead, in general terms, savings are determined by comparing measured consumption or demand before and after the implementation of the PED, following the measurement and verification approach specified by International Performance Measurement and Verification Protocol (IPMVP) (Figure 2) [2] or with a reference situation, making suitable adjustments for changes in conditions. Good practice requires that the estimation of the baseline is well integrated into the process of identifying, developing, and deploying ATELIER interventions or any other energy conservation measures.

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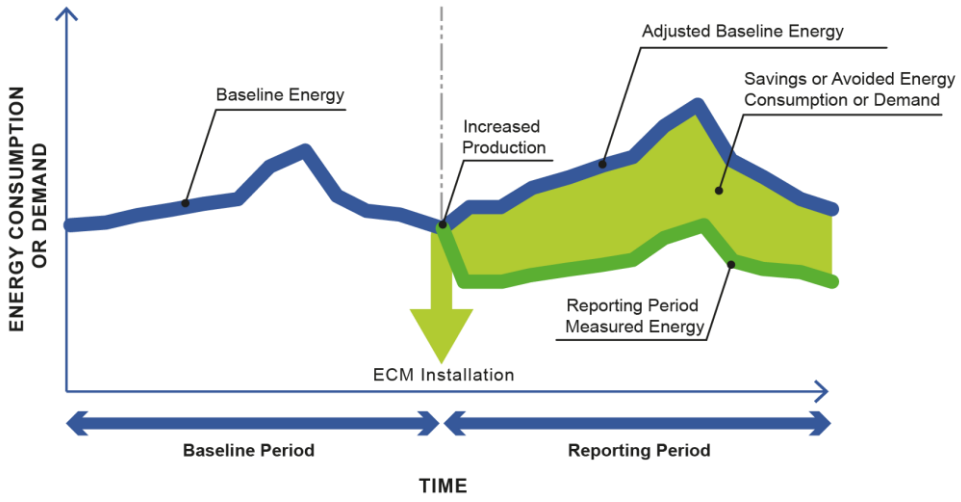

Figure 2. Illustration of baseline, reporting before and after implemented measure and resulted savings using the example of energy consumption (from: International Performance Measurement and Verification Protocol, IPMVP)

In some cases, the choice of the baseline is straightforward, because the specific measure would not have been taken in the absence of the project. An example is battery storage for flexibility. However, in many cases, the baseline will reference either the existing situation or business-as-usual. For example, the baseline energy use of a new constructed building could be based on existing regulation [3]. This would require an ex-ante estimation, which is often not an accurate predictor of actual energy use. Therefore, transparency in the choice of baseline is most important.

The general idea concerning the baseline estimation in ATELIER is that: '*the baseline or reference value represents the state without the interventions being implemented*'. The baseline approaches to be followed for ATELIER interventions include - (1) retrofit interventions, (2) new interventions, 3) project specific interventions and 4) economic, social and regulatory interventions.

1) Retrofit intervention baselines

Where the ATELIER intervention is an improvement to an existing technology or building, or is the substitution of a previous system for a highly efficient one, it is important to consider the energy consumption data (includes final energy demands for heating, domestic hot water, cooling, lighting, etc. and their emissions) for the system for a period of one year before renovation has started. The consideration of this 'historic' performance data to identify where improvements have had substantial impact.

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2) New intervention baselines

With no existing data to compare the performance of new systems and infrastructure, it is important to define a baseline based on the performance of systems representing minimal requirements by law, i.e. buildings of similar size and purpose, or mobility systems in similar districts or cities. If applicable, calculations should be based on actually recorded outer variables, for example actual weather data for the monitored site for better comparability.

3) Project specific intervention baselines

As some ATELIER interventions are designed specifically for implementation in each Lighthouse City there will be no other such projects to which the interventions can be measured against. For example, the effect of battery storage on the energy system. If possible, we would evaluate the measure as part of the global installation, otherwise, the baseline for measurement and comparison will be zero (0).

4) Economic, social and regulatory intervention baselines

In the case of economic interventions, including those targeting business development, a project specific baseline of zero (0) will be applied.

In the case of social interventions, the baseline will be considered zero (0) for output-oriented KPIs, where concrete indicators for monitoring the progress and effectiveness of implementation of project activities can be measured. For example, a count of the number of stakeholder meetings.

The baseline for social interventions with qualitative process-oriented KPIs, will be measured during the early stages of project implementation. For example, the baseline measurement to assess perceived quality of life (QoL) will be measured around 20 months into the project.

Multiple baseline scenarios are needed to assess the impact of regulatory interventions. A “no action” baseline scenario will be modeled assuming no change in the regulatory program under consideration. This does not necessarily mean that no change in current conditions will occur over the course of the project. A “future state” baseline scenario will be modelled to reflect the likely trajectory of enabling policy, legal and planning frameworks in the LHCs and FCs.

2.4 Expected impact, targets and benchmarks

ATELIER has set targets for the performance of the PED demonstrations and the other project interventions and activities. The targets are related to the baseline. Whether or not the target has been met, in combination with the underlying causes, are an important input to the evaluation. To this purpose, for the KPIs in the M&E framework, baseline and targets are established. These can be quantitative or qualitative; hard or soft; specific or indicative.

The source of the targets is multiple. Starting point is the design of the PED demonstrations and of the project as described in the proposal and subsequent revisions. In addition, in the M&E related activities the targets are further specified, in particular by drawing on the best

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practices of other SCC projects, benchmarking with results of other projects, and on the international progress in PED design and assessment.

2.5 Defining the system boundaries and temporal scales

Each of the specific actions and/or interventions implemented in the LHCs or FCs are applied to have a certain impact within predefined and delineated system boundaries. The following table defines the system boundaries within which ATELIER's KPIs and their baselines will be monitored, evaluated and defined (Table 2). Note that a certain indicator or its baseline can be evaluated or defined at multiple scales (or within multiple different system boundaries) if necessary.

Table 2: System boundaries of ATELIER monitoring and evaluation framework

KPI framework reporting level	Description
Area/Site	Smallest level of intervention, for example dwelling, building or street level. It might be related to specific interventions or actions (according to the DoW, 51 actions in Amsterdam and 58 in Bilbao)
Positive Energy District (PED)	The interventions, deployments and specific actions that affect the PED demonstrations as defined in the DoW: • **In Bilbao**: the PED is defined as three interconnected areas at the North, Centre and South of Zorrotzaurre island that include positive energy blocks, energy networks, electromobility, smart infrastructure, etc. • **In Amsterdam**: the PED is defined as the sum of interconnected (smart grid) elements that include 2 new residential areas (combined with other functions), existing housing, renewable energy generation plant, and electromobility hub.
District	The entire neighbourhoods where PEDs are located are going to be tackled and upgraded by the solutions for integration and connectivity (smart grid, energy trading services, electromobility, geothermal generation, etc.). • **In Bilbao**: Zorrotzaurre island, conceived as core element of demonstration and replication of the smart city strategy of Bilbao, and indeed the PED in Bilbao is borned naturally upscaled/replicated in the whole Zorrotzaurre island • **In Amsterdam**: The demonstration district cannot be uniquely defined as a geographical area, contrary to Bilbao. The virtual PED is located in an administrative district Buiksloterham. However, the definition of the demonstration district will depend on the specific impacts that are assessed. For instance the broader district energy system, of which the PED is a part, will have

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	different borders than the area around the PED of which the citizens will be involved because they have a link with the PED demo.
City Level	There are ATELIER actions that apply to the entire city. The Innovation Ateliers, for example, involve public administration, research entities, industry and citizens of the entire city. At the same time, and in terms of impact assessment the energy performance of the PED will be estimated with broader boundaries moving from the district level to, for example, the city level.
Project Level	The project level comprises impacts within ATELIER as a project, which could include impacts from all the implemented actions or impacts created throughout all the project activities, and assess the results in relation to the project's objectives and targets. At the same time, this is the highest level of aggregation of intervention targets or expected impacts. At this evaluation level we could for example, evaluate how far we are from the overall energy surplus objective of 1,340 MWh (primary energy), how much we have contributed with SCC partnership, or how many relationships have been established among the 8 cooperating cities (2 LHCs and 6 FCs)
Technology Level	Some of the KPIs need to be evaluated at the technology level, for example, the cost of carbon mitigation can be quantified for each of the implemented technology (eg, solar PV, geothermal network, improved insulation, etc.), so that priorities among technologies can be better understood, considering different local context (e.g. climate, stakeholders, etc). This is especially essential as the financial budget for replicating the smart city solution can be limited, thus in-depth and up-to-date understanding at the technology level is important, and solutions shall be prioritized depending on their performance at the technology level.

With regard to the applied temporal scales, ATELIER aims to measure and store the data at the finest temporal resolution and with the highest quality standards, yet it is still affordable and at the same time useful in terms of evaluation and impact assessment. Finer temporal scale is preferred as the data monitored at finer temporal scale can be always processed and converted to a more aggregated level. The differences between data, metadata and KPI are explained in section 3.8.

2.5 Main evaluation areas for project and PED evaluation

As a starting point for evaluation, we have drafted the main questions that the ATELIER evaluation should answer. These questions bridge the link between project evaluation and the corresponding recommendations.

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The questions are preliminary and will be discussed. The evaluation framework that will build on these questions will finalized the coming period. It is important that we achieve consensus on these questions throughout the project team. These evaluation questions cover both the PED demonstration as well as the other interventions and activities of the project.

1. What are the characteristics of the generic PED design that the demo represents? What is the contribution of the specific technological components/innovations of the demo to its performance? What are essential design elements and what are variations with a certain design?
2. How do the ATELIER demo PEDs perform in terms of GHG emissions and energy positivity? Does the demo have a net energy surplus and zero GHG emissions. If not, why not? In conclusion, can the PED concept be validated?
3. What is the (positive or negative) impact of the PED demo on the wider district and city in which it is located? What happens with the area between de PEDs.
4. How can the PED demo be upscaled and replicated within and across cities? If yes, for what kind of cities?
5. What is the contribution of the upscaled and replicated PEDs to the city's long term targets in energy transition, climate and circularity?
6. How should citizens and stakeholders be involved in PED planning and PED design, roll-out and city planning?
7. What business models are needed to secure roll-out and replication and how can the business case be established?
8. How should policy makers and legislators promote and speed up PED implementation and scale-up in city planning? What information and capacity for cities is needed for PED implementation and scale-up?

2.6 Project Evaluation Framework for PEDs

The ATELIER project will establish a common framework to evaluate project outcomes and impacts in the domains of energy, environment, economic impacts and business development, mobility, social impact and citizen engagement, governance and upscaling/replication, and, finally, knowledge generation and dissemination. The evaluation will consider both direct and in-direct impacts of the project both within the boundary of the PEDs and in the broader context at the City/EU level. Direct impacts refer to the expected impacts resulting from ATELIER interventions. Whereas in-direct impacts refer to the secondary impacts which occur not as a direct result of the project but are often associated with complex systems and pathways (Figure 3). The framework will also consider and build upon the approaches to evaluation by other SCC projects.

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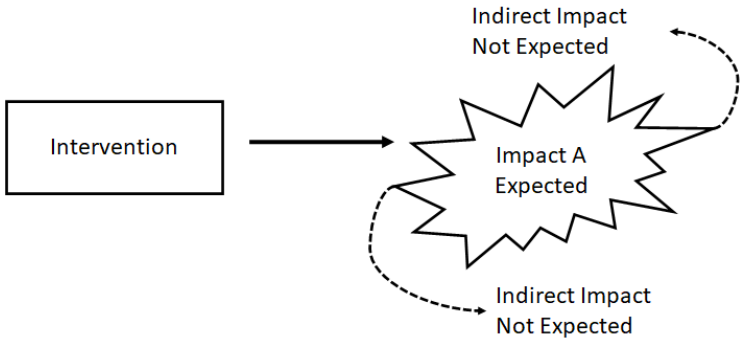

Figure 3. Indirect impacts occurring not as a direct of the ATELIER project

A performance-based approach to evaluation (Figure 4) is beneficial where we can measure to what degree the original project objectives and subsequent interventions have been achieved. A performance-based approach will provide a useful framework for analysing causal logic and assumptions in the project. It should provide explanations as to why interventions did (or did not) lead to the desired outcomes, and help identify assumptions, enabling factors and stumbling blocks. A performance-based approach considers the key actors and their role in realising high-level change and how the interventions contribute to change.

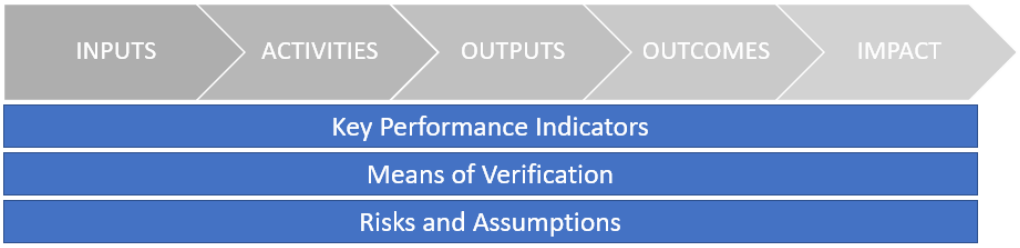

Figure 4. Overview of performance-based assessment approach to evaluation

In the case of innovation projects such as ATELIER, it may not always be possible to measure the direct outcomes and impacts. As such, some parts of the project will require an alternative approach to evaluation. For example, when evaluating system innovation, a reflexive approach that focuses on both a collective learning process as well as on the results in terms of learning and institutional change will be more applicable. Figure 5 provides an example of how a reflexive approach will be applied in the Innovation Ateliers to learn about the deployment process of the innovation Ateliers. Each cycle of the reflexive approach outlined below contains five steps: observe, analyse, reflect, adapt and report.

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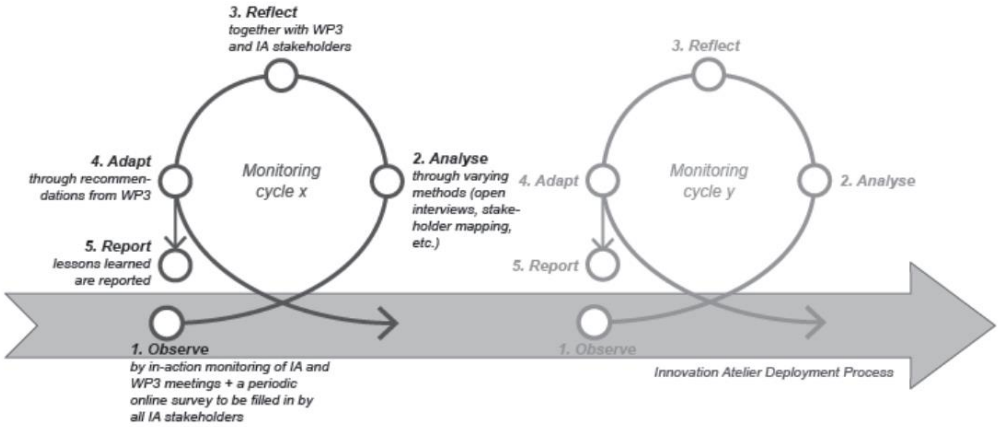

Figure 5. A visual representation of two reflexive monitoring cycles in the Innovation Atelier deployment process

The project evaluation framework for PEDs will integrate a traditional performance-based assessment approach together with a reflexive approach. The project evaluation framework for ATELIER proposes to include periodic cycles of reflection to better understand what is working and what is not working and correct course throughout the project life.

The basis for project and PED evaluation is a thorough and transparent understanding of the technical, economic and social system that depicts the interactions, causal relationships, internal parameters determining the relationships, and external conditions and assumptions. The ATELIER interventions can be placed within this concept, as they target to change specific parameters and/or relationships. This can be called a PED Theory of Change or PED Ecosystem, but we will call it the “Project Evaluation Framework for PEDs” to stress its function for evaluation.

Below we present an example of one area of the PED concept to illustrate our approach:

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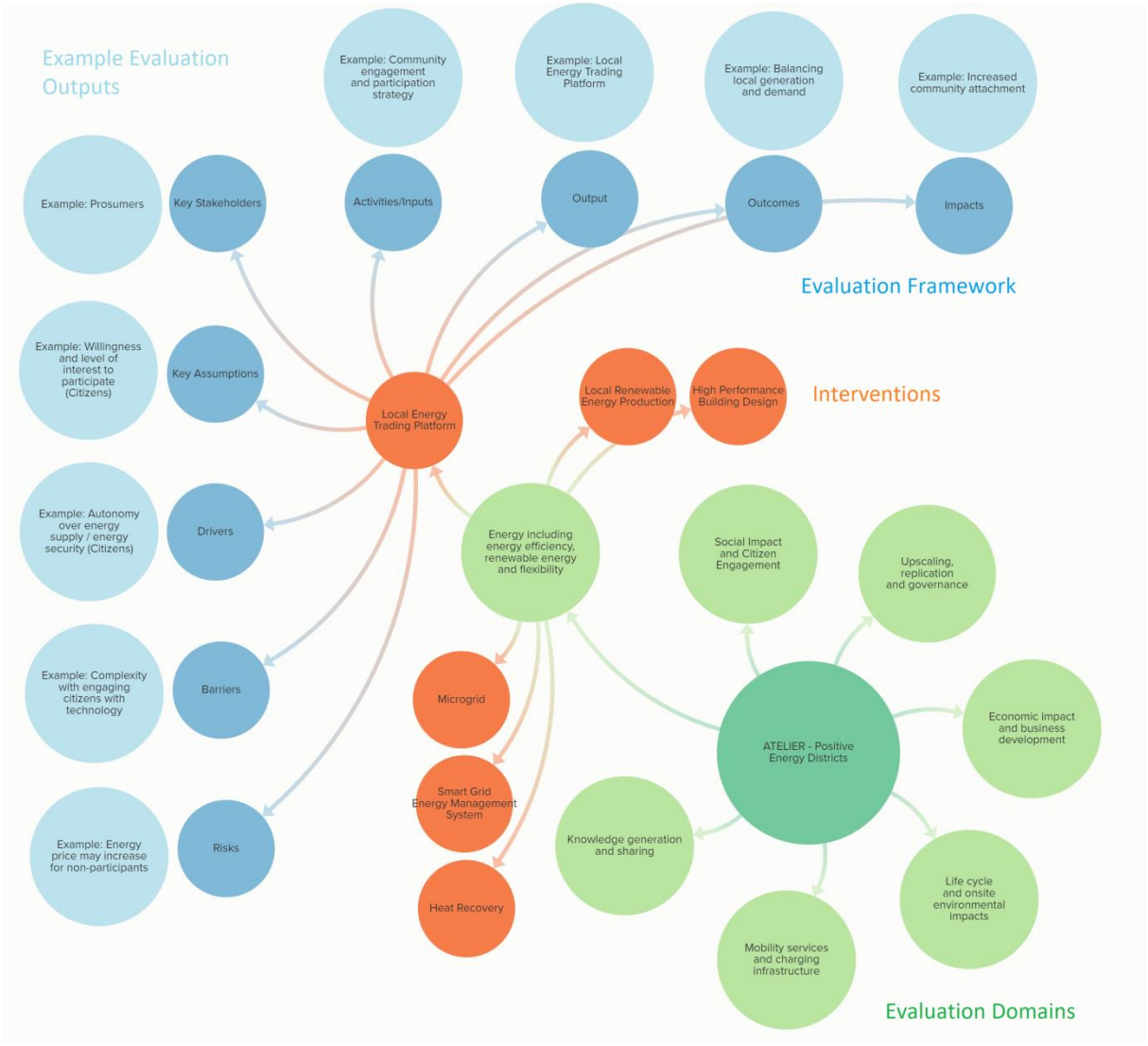

Figure 6. Example PED ecosystem map for the local energy trading intervention

The example ecosystem mapping (Figure 6) for the local energy trading intervention describes all the entities, flows and relationships that characterise the surrounding relationship. The ecosystem mapping provides a starting point to identify aspects of the intervention where a performance-based approach to evaluation used together with key performance indicators does, or does not, adequately capture the full value of the intervention. Ecosystem mapping can also identify areas where key performance indicators do not link directly to the expected impacts of the interventions and where an alternative approach to evaluation may be needed.

The PED ecosystem is being mapped and developed currently; all project partners will be involved, as a common understanding will be established within ATELIER. It will be applied first in the 1st interim project and PED evaluation (month 36) and further updated and refined subsequently.

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2.7 State of the art in the evaluation of smart city projects and PEDs

All smart city projects, including the SCC projects, monitor and evaluate extensively. In ATELIER, several initiatives are ongoing, facilitating the exchange and harmonisation of M&E approaches across smart city projects, including the SCC01 Task Group on Monitoring and Evaluation, in which ATELIER participates.

We note, however, that the scope and approach differ between projects. ATELIER intends to build on these experiences to further improve evaluation approaches.

- Evaluation is often focused on the monitoring of the performance of the pilots and demonstration areas with less attention to other activities of the project.
- Interim evaluation is seldom explicitly reported. The main reporting is on the final evaluation.
- The link of evaluation with the recommendations and other project products directed is often not explicit.
- Few projects have established a theory of change / logical framework as the basis for evaluation.
- Most projects base their M&E framework on KPIs with limited clarity how evaluation areas are addressed that are difficult to capture in KPIs, such as citizen engagement.
- Projects sometimes use KPIs capturing outcomes and not impacts. Examples are the number of stakeholder events organised, which is a poor indicator for the actual impact of stakeholder engagement indicators.

We recognise that evaluation of smart city projects can struggle to capture the complexity and multi-disciplinary character of these projects, and to translate the results to best practices and recommendations. ATELIER aims to bring innovation to the M&E approaches, in strong collaboration with other SCC PED projects. To this purpose, ATELIER participates actively in the SCC01 Task Group on Monitoring and Evaluation and in other platforms.

We note an average trend towards a smaller number of KPIs over time, possibly reflecting the experience that, while a large number of KPIs can better reflect the variety of impacts, many are difficult to monitor and difficult to translate into evaluation conclusions. Also, the transparency of the monitoring framework decreases with increasing number of KPIs. However, the difference can be explained partly by a different level of aggregation of KPIs and standardisation. We will continue our efforts to exchange experiences between projects on KPI definition with our fellow SCC PED pilots with the goal to secure common understanding and harmonisation, also through supporting the SCC task group on M&E.

In chapter 3 on the selection and definition of KPIs, we will refer in more detail to the state of art and best practices in monitoring, in particular the selection of KPIs.

2.8 Domains for evaluation

The concept for project and PED evaluation covers a wide range of areas/domains. Therefore, we will structure our evaluation framework (and the underlying KPIs) accordingly. Also, we have harmonized this grouping with the current practice in SCC projects to facilitate comparison of evaluation results. It should be noted that this grouping is to some extent a

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simplification as these areas partly overlap. For example, the amount of renewable energy production is an energy KPIs, while at the same time a parameter used for calculation of GHG emission reduction in the environmental area. Also, the main questions for evaluation will be answered in most cases, by the combined monitoring of KPIs in different areas.

We distinguish the following evaluation areas (Figure 7):

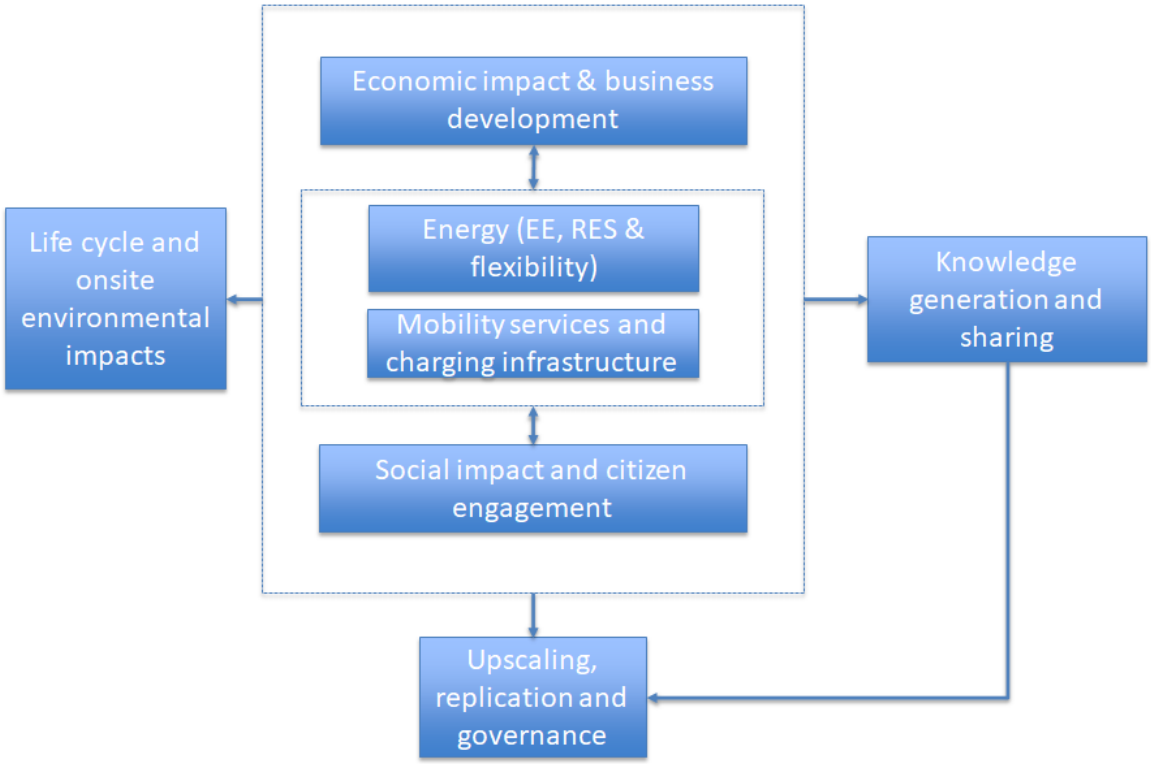

Figure 7. ATELIER evaluation areas for monitoring and further impact assessment

In the following sections, we describe the scope of evaluation areas and the relation between them. In chapter 3, the monitoring approaches for these domains, including KPIs, are discussed.

Evaluation domain 1. Energy including energy efficiency, renewable energy and flexibility

The main objectives of PEDs are related to the energy performance. Furthermore, the energy performance has a direct impact on the environment, and on other areas, such as economy and business development.

The reduction of CO_2-e emissions is realised through deployment of local smart urban solutions, addressing (a combination of) technical, financial, legal, and social measures, that support system integration, local production of renewable energy and high energy efficiency and stimulate local public and private investments.

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Achieving surplus energy in the PED demonstration (energy positive) is an important target in ATELIER. At the same time, the energy performance should be considered in terms of its scale-up and replicability potential and the insights that are derived from the demo. A PED demo that misses the target, but that can be further improved and replicated in the future is worth much more than a demo that proves energy positive but is a one-off, without replication potential.

Figure 8 shows the four components of the PED energy system. Area 1 to 3 will be evaluated in the energy domain; area 4 in the mobility domain.

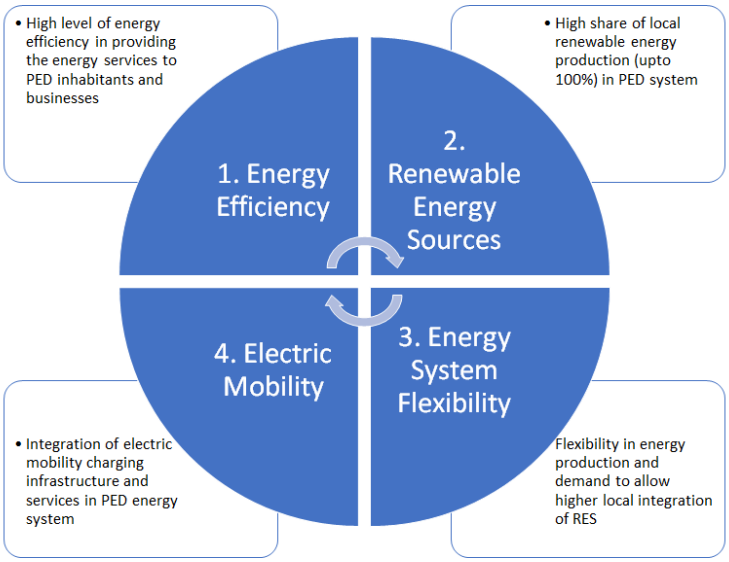

Figure 8. Four components of PED energy system. [SCIS Solution Booklet on PED, to be published]

Evaluation domain 2. Mobility services and charging infrastructure

We distinguish between two areas:

1. E-mobility charging infrastructure will be integrated into the PED smart grid and part of the PED energy demand as well as, through smart charging and vehicle-to-grid contribute to the flexibility management of the PED energy system
2. Smart mobility services will be provided in and around the PED areas, which intend to 1) reduce car density and usage and 2) shift away for fossil-fuel transport.

The M&E of area 1 will be strongly linked with the evaluation of the energy performance; area 2 will address ATELIER's impact on mobility demand and usage in the PED area.

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Evaluation domain 3. Life cycle and onsite environmental impacts

GHG emission reduction is a main impact expected from the PED. In addition, we evaluate other environmental areas, of which we expected they could be influenced by the PED interventions (positively or negatively). We address these at different levels: 1) direct impact of the PED demos, 2) impact in the wider district, and 3) city-level in case PEDs are upscaled and replicated. In addition to monitoring the environmental impact onsite, we will assess life-cycle impacts as well (up and downstream) using Life Cycle Assessment (LCA). This will be further explained in section 4.2.

Evaluation domain 4. Economic impact and business development

The large-scale deployment of PEDs requires the development of sustainable business models that consider the whole process of building, operating and maintaining PEDs. There is no predefined business model for the successful development of a PED. Instead, a combination of different business models for each stakeholder involved (cities, real estate developers, building owners, providers of innovative technologies, energy infrastructure operators, inhabitants…) within each of the pillars of PED energy systems (energy efficiency, renewable energy production, energy system flexibility and electric mobility) has to be found.

Evaluation domain 5. Social impacts and citizen engagement

The success of implementing PEDs will not only depend on the availability of technical solutions but also of social, political and business commitment. The energy transition is a multi-level phenomenon, involving cultural and societal aspects next to planning and finance, for example. In order to achieve a truly sustainable and 'smart' energy system, that is secure and affordable for all citizens, the social dimension needs to be addressed upfront and throughout.

Citizen and stakeholder engagement is an important means through which to achieve this. Putting the goals and aims of the engagements first, the project defined different methods, tools and forms of participation leading to our main objectives. The main objectives are:

- Users of the PED can embrace innovation and technology and are able to efficient use natural resources: they have a positive (Social) Acceptance of ATELIER solutions and are equipped to be active in the PED as energy prosumer
- People involved in the PED are able to be actively involved in the project, raising issues and co-create solutions

This will lead to: more awareness about sustainability and a change of moral and habits affecting more sustainable behaviour and the reshaping of energy-related social norms (what it is considered normal in society). Also, living in a positive energy district leads to a greater feeling of well-being and improves the average quality of life.

In ATELIER, we will build on the best practices and develop an innovative approach to monitoring using a mix of quantitative indicators and qualitative dynamic evaluation methods. We will complement the performance-based M&E approach, for which KPIs have been identified with the reflective evaluation approach.

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Evaluation domain 6. Upscaling, replication and governance

The PEDs that are being piloted currently throughout Europe only have value if their concept can be upscaled and replicated (Figure 9). PEDs are inherently scalable and should grow. They are an intermediate step in the energy transition, so the core concept is the growing integration of local renewables and the fulfilment of all local energy needs.

Upscaling refers to extending the initial PED by adding buildings, energy production facilities and other components. The upscaling of PEDs is important to enable the integration of renewable energy sources and expansion of smart energy solutions. The initial design of a PED can influence success factors for upscaling, e.g. the selection of off-site renewable energy in one PED limits the options for the next PED. For a demonstration pilot, a certain area needs to be chosen, but the growth path should ideally already be present as part of the plan. In ATELIER, upscaling is relevant for the Lighthouse cities and the PED demos.

Replication refers to implementing a proven PED concept (including technologies, business models and governance) in the city or in another city without a direct connection to the initial PED. PED solutions can be replicated by adapting the original idea to a new context, creating a comparable project in another location. Assessing the feasibility of replicability includes determining parts of the PED that can be transferred directly, and which need to be adapted. Replicability should also consider the local context, geographical and regional differences as well as differences in political, planning and ownership structures. In ATELIER, replication is relevant for the Fellow Cities as well as for the Lighthouse cities (replication in other areas of the city).

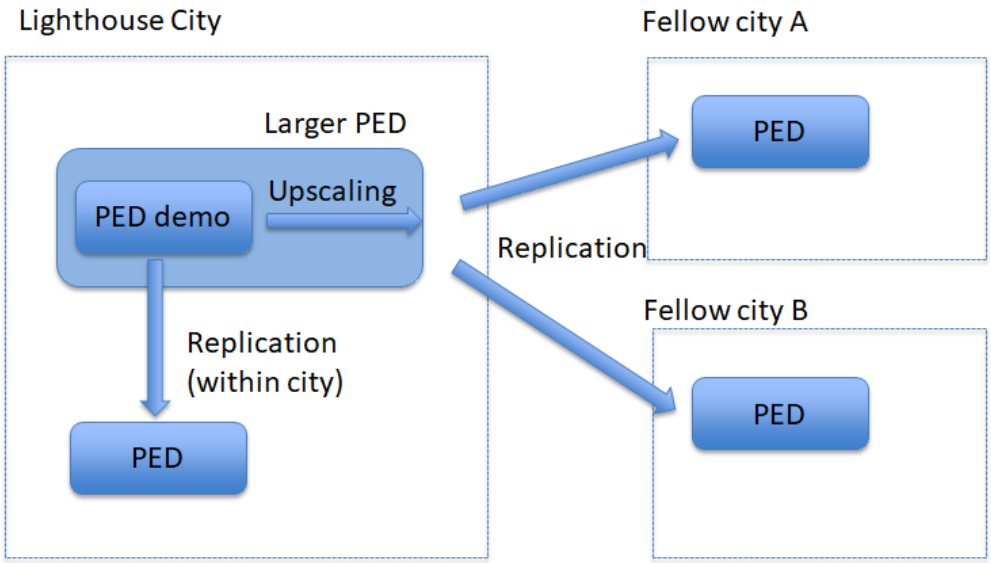

Figure 9. Replication and Upscaling in ATELIER

Upscaling and replicability require different M&E systems. The upscaling potential depends strongly on the area directly outside the PED demo location, the capacity of the PED energy system to accommodate new demand and supply, and the specific business case for

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upscaling. Changes towards supporting governance, regulation, and city planning are subject of evaluation also.

Governance refers to the city governance by the municipality as well as the governance of the PED itself. This includes administration, planning and financial management. It also includes legal and regulatory aspects and the compatibility with the PED solutions. Often, in other projects, governance is regarded as a separate evaluation domain. However, as governance is instrumental to upscaling and replicability, we include this in a single domain.

Evaluation domain 7. Knowledge generation and sharing

Within ATELIER, at different levels and in different groups of activities, much knowledge will be produced both intrinsically, e.g. in the implementation of the PED, as well as extrinsically, in the research activities. However, this knowledge needs to be captured, shared through broader research, learning and dissemination activities. This is a challenge as the knowledge owners within the project are often engaged fully in their core activities with limited time for sharing. In ATELIER, the collaboration with SCC projects and the activities related to dissemination and exploitation of project achievements, products and results will be organised and facilitating knowledge sharing

ATELIER will monitor and evaluate the quantity and quality of the knowledge generation and sharing. In ATELIER, this is regarded as an important instrument for collaboration and communication with other projects of the SCC community and beyond.

2.9 Limitations of KPIs in M&E

A Key Performance Indicator (KPI) is a number or value which can be compared against an internal target, or an external "benchmark" to give an indication of performance. They are commonly used in M&E frameworks as they provide both transparency and focus in the monitoring process. ATELIER will, therefore, also apply a set of KPIs (see chapter 3). However, it is important to remain aware of the limitations and risks associated with the use of KPIs:

1. **Simplification.** A balance needs to be made between the number of KPIs used and the level of detail and comprehensiveness of the monitoring. It is inevitable that a typical number of 30-40 KPIs for such a complex and broadly scoped project only can cover part of its impact.
2. **Bias:** Some evaluation areas (e.g. energy) are easier to capture impact into clearly defined, quantitative impacts based on metering. Others are for more difficult (citizen engagement). The risk is that in evaluation more attention is paid to the “easy to quantify” impacts, which are not necessarily the most relevant ones.
3. **False sense of accuracy and precision.** When drawing conclusions on the performance of KPIs, it is necessary to be aware of the KPI’s accuracy and precision. Accuracy is closeness of the measurements to a specific value, while precision is the closeness of the measurements to each other. For example, reporting that the PED

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has achieved an annual surplus of, say, 10 MWh, means nothing if accuracy and precision are not reported at the same time.

2.10 Embedding monitoring and evaluation into the ATELIER project set-up

Following the objectives of M&E of the ATELIER project, work package 9 (WP9) is closely embedded in the project with linkages to almost all work packages of ATELIER (see Figure 10). The WPs will play a leading role in the selection of KPIs and in their monitoring, supported by WP9. For the more cross-cutting evaluation areas, WP9 acts as coordinator and secures the integration of the monitoring results from the other work packages (WPs).

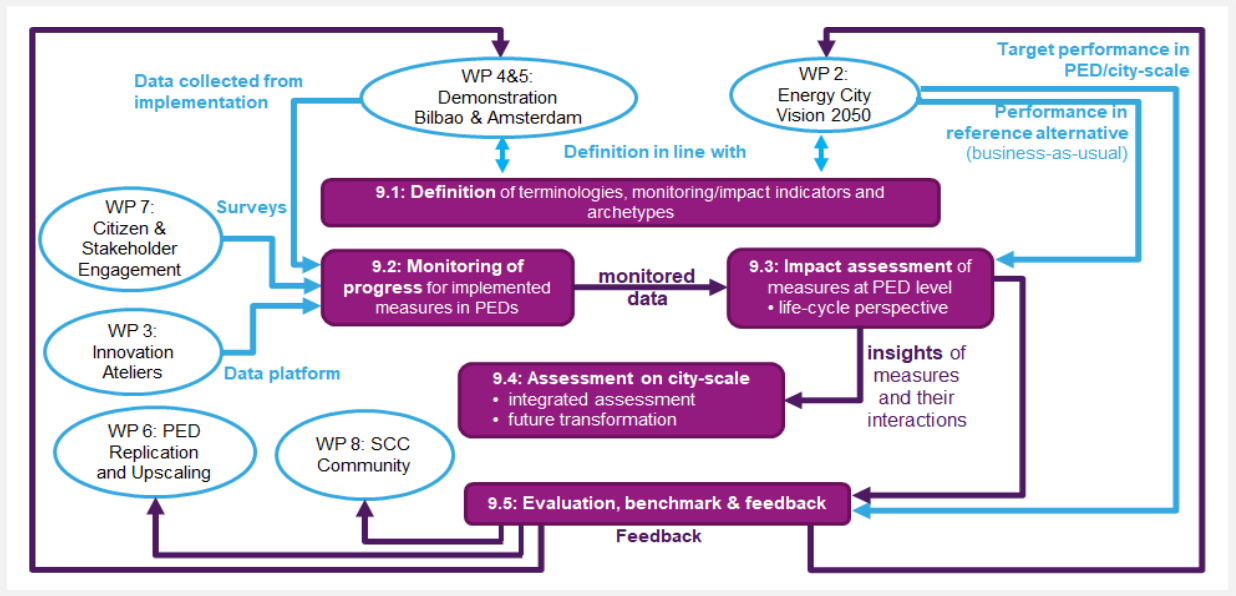

Figure 10. Monitoring and evaluation embedding in ATELIER project set-up

The graph puts WP9 in a central position. The report at hand is a first step in WP9, establishing the first concept of the M&E framework. This will be subject to consultations with all work packages over the coming period. Monitoring has already started of those WPs that do not directly rely on the implementation of the PED demos (WP7, WP3). In some evaluation domains impact assessment is necessary to assess the impacts of the PED solutions. For example, this is the case when assessing the district and city level impact of the PEDs. Subsequently, the project will translate the results of the PED interventions and the impact assessment to conclusion on city level. This has strong links with WP 3, 7 and WP2. Finally, all monitoring results and the outcomes of impact assessments come together in the evaluation chapter, which provides feedback to all project WPs.

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3. Selecting and developing KPIs

3.1 Structuring the KPIs

The main list of KPIs has been developed following a bidirectional approach: A) bottom up; moves from specific data being gathered at the demonstration areas to answering the evaluation questions, B) top-down approach looks at other EU standards and smart city projects (section 3.3) to come up with a proposal that will facilitate the communication with smart city platforms and networks.

The KPI-based M&E framework combines a top-down and bottom-up approach where the KPI's aim to address the project's top-level PED performance questions as well as to examine detailed performance data related to specific actions and interventions of the project. With this combined approach we address the major overarching M&E objectives of ATELIER while reflecting specific data-driven M&E needs. The approach leads into ATELIER's KPI/Data Pyramid which consists of KPIs at different levels backed by a rich compilation of monitoring data at high temporal and spatial resolution.

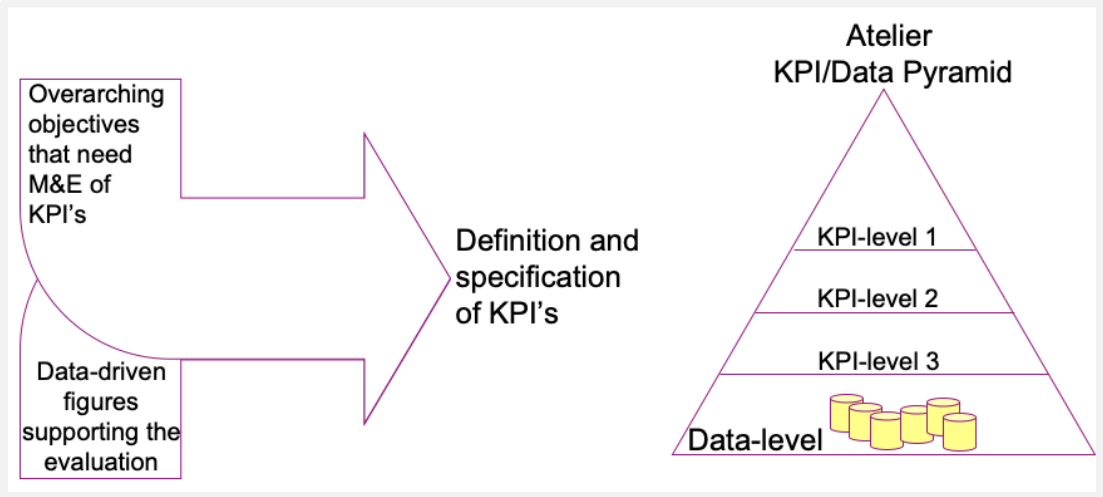

Figure 11. Monitoring and evaluation embedding in ATELIER

The different KPI-levels reflect different aggregation levels, where level 1 deals with overarching project objectives related to the two demonstrators in Amsterdam and Bilbao; level 2 refers to specific objectives of individual project activities and their related interventions and actions. Level one and level two are core KPIs of ATELIER, where level 3 provides supporting information as needed for an in-depth evaluation of higher-level KPIs.

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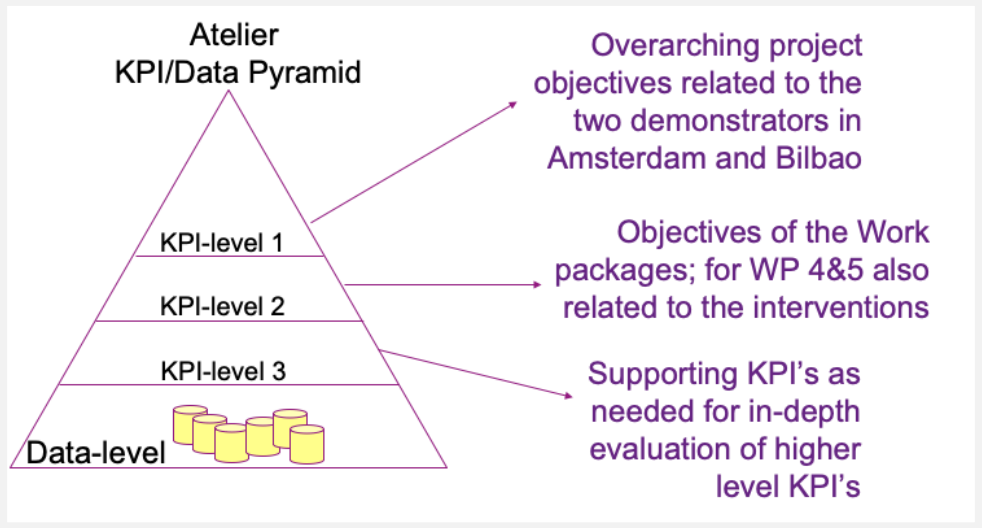

Figure 12. ATELIER data pyramid and related objectives in the project

KPIs of different levels may have linkages where a higher-level KPI builds on lower-level KPIs and uses the corresponding data to compute. An exemplary sketch of different KPIs and their levels, including KPI interlinkages is provided in Figure 13.

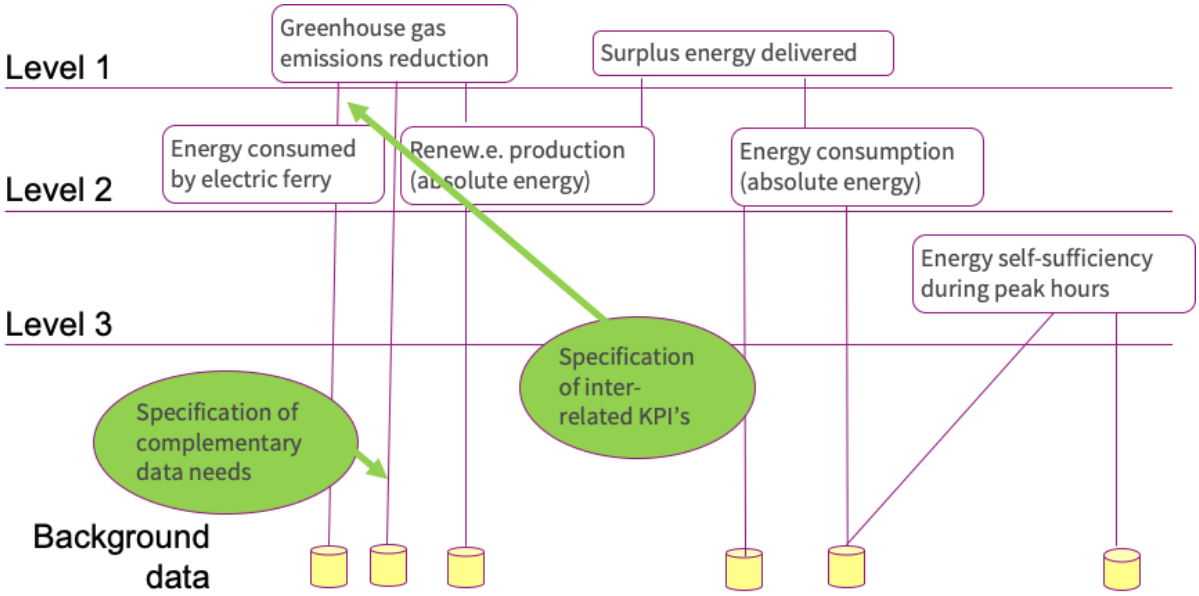

Figure 13. Example of KPI computation levels and interlinkages on specific data needs

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3.2 Criteria in selecting and developing KPIs

When selecting and defining ATELIER core KPIs we followed the parsimonious concept. That is, the ATELIER M&E approach balances between having a very long list of indicators that closely monitor specific interventions and estimating only those holistic (lumped) KPIs that would assess the main impact questions without understanding the contribution of specific actions. Therefore, the proposed criteria might result in a complete yet concise list of KPIs.

Following the proposal of CIVITAS framework [4] as well as other closed EU project selecting criteria (POCITYF, CityKeys, etc.), the M&E approach will select a comprehensive list of indicators that reflect the direct and indirect impacts of the implemented measures. The ATELIER attaining criteria are:

1. **Relevance:** Indicator should have a significant importance for the evaluation process and serve as much as possible the ATELIER objectives and city (LH and FC) needs. The indicators should be selected and defined in such a way that the implementation of the smart city project provides a clear signal in the change of the indicator value.
2. **Availability:** Data for measuring the indicator should be easily available (limited time and effort needed). Indicators should be based on data that will be provided by the data owners (developers, solution providers, etc.) or collected from a deployed sensoring system or open (public or private) services.
3. **Measurability:** The indicator should be capable of being measured, preferably as objectively as possible. Indicators that seem to be too much disturbed by interventions not directly linked to ATELIER action would be avoided.
4. **Reliability**: The definition of the indicator (and the calculation method) should be clear and not open to different interpretations. ATELIER's indicators will be common to the two LH cities and their corresponding PEDs. The calculation method might be slightly different in terms of the frequency of measurements, specific variables considered, etc. We will make these differences clear and try to minimize them.
5. **Familiarity**: The indicator should be easily understood by users and non experts. ATELIER provides a complete description of the indicators and the references that allow estimating them in a transparent manner. The names of the indicators are clear and self-explicative.
6. **Complementarity**: the indicator should keep a low correlation with the others representing a clear differentiable effect or impact and therefore, the indicator provides an added value to the evaluation process.
7. **Benchmarkability**: the indicator should support comparability to reference values for which it is necessary to provide a clear definition of the baseline (BAU) and if needed other reference values of different sources. The indicator should support to be reasonably aggregated or disaggregated if necessary, therefore allowing the estimation at different geographical boundaries or temporal scales. As such, the indicator should build on flexibility and transparency of data and calculations, to ensure that the underlying data can be properly used for the parameters interpretation in relation to comparative values. In addition, the indicator can be subject to normalisation along different dimensions in order to support benchmarking across interventions and different components of the ATELIER PEDs or also with other SCC projects.

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The structure and set-up of the KPIs supports the assessment of the KPI's along multiple thematic, spatial and temporal dimensions in a structured way and to capture the different aspects of the project's M&E ambition. As such, it will allow to evaluate the performance of the PEDs in order to provide feedback to PEDs as well as to benchmark against other SCC projects, as well as to assess impacts not only for operation of PEDs but also complemented by life cycle analysis (LCA) expanding the broader perspective beyond the PEDs. KPIs will be included for reporting to the SCIS platform as well as to support engagement in the broader SCC community, such as in the SCC01 task force on monitoring and evaluation and the joint EERA programme on smart cities.

3.3 State of the Art - KPIs for smart city projects and PEDs

ATELIER is not the first project that explores the concept of smart city and positive energy districts. Therefore, it is important that the approach developed in the M&E group of activities is built on a comprehensive review of M&E frameworks carried out in the past and other ongoing SCC projects and PEDs, so that the state of the art in M&E is summarised to better facilitate future SCC projects and initiative. The principal of the M&E framework is to facilitate common and transparent data collection, performance measurement which allow comparability and future replications. There have been several leading initiatives in the EU promoting cooperation and exchange of know-how among smart cities, including European standards (e.g., ISO 37120:2018, ISO 37123:2019), M&E frameworks applied in other SCC projects, as well as strategic plans and initiatives (e.g., UN's Sustainable Development Goals), which provide indicators for assessing the performance of smart city solutions. This section will focus on reviewing the M&E frameworks applied in the existing approaches (Smart City Information System (SCIS), CityKeys, Espression), standards and other SCC projects. In the meanwhile, aspects that have been well addressed and require further improvement are identified and incorporated into the M&E framework tailored for ATELIER.

Smart Cities Information System (SCIS)

SCIS is funded by the European Commission and the aim of this platform is to provide a knowledgeable database where stakeholders from across Europe can exchange data and knowledge for the further successful deployment of an insight into a smart city. This web-platform is powered by former projects, it gathers a large number of experiences, like know-how, data on the creation of smart cities and an energy-efficient urban environment.

The purpose of the SCIS monitoring framework is to enable performance evaluation and comparison between different initiatives and projects. SCIS gathers and exchanges information from a wide spectrum of projects including Smart Cities and Communities (SCC), Energy-Efficient Buildings (EeB) and designated projects funded under the calls for Energy Efficiency (EE). Owing to the complexity and variety of the projects in the scope, the indicators are proposed to be calculated for different granularity levels (building, set of buildings, energy supply unit, set of energy supply units, neighborhood) as can be seen in Figure 14.

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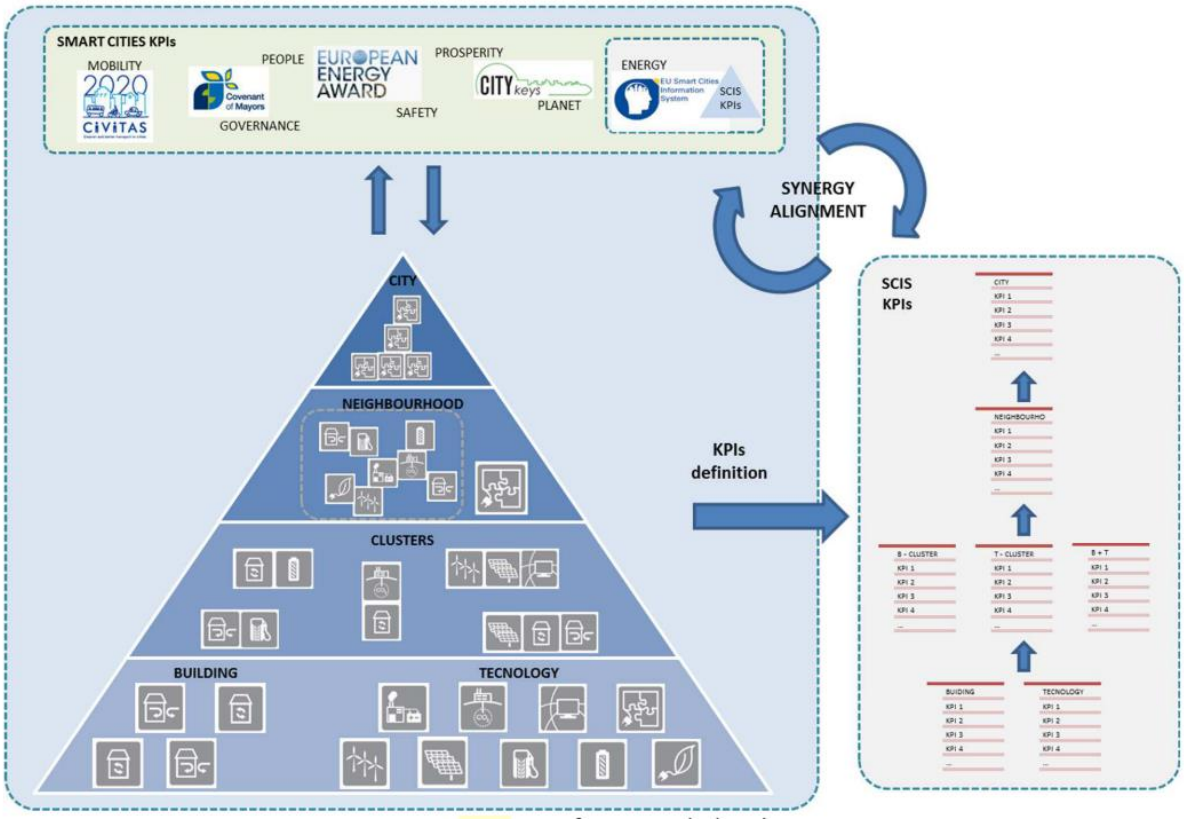

Figure 14. SCIS KPIs framework development [1]

So as to assess the performance of the ongoing project SCIS KPI framework focuses on indicators which thoughtfully evaluate the overall performance of the project. SCIS had split into two groups KPIs according to their importance: core KPIs, and supporting KPIs. Core KPIs are featured in a group of KPIs clustered in five domains such as technical, environmental, economic, information and communication technology (ICT) related, and mobility related technologies. In total the SCIS framework presents 27 core KPIs that were already proposed in former strategies and projects at energy and environmental domains. SCIS proposal is approaching the standardisation of monitoring and evaluation frameworks.

The SCIS system also provides the Self Reporting Tool (SRT) that has become the main information system where cities provide monitoring and evaluation insights. Actually, the objective pursued by SRT is to make sure that all the relevant outcomes, learnings, experiences and insights derived from SCIS project interventions could be collected, safeguarded, analysed and used to inform the replication of smart city initiatives at different regions [5], so as to ease the replication and upscaling.

The platform provides project partners and data providers with pre-defined templates for their specific project data inputs, which will be stored and managed within the SCIS database. Based on this information repository, the platform generates automated analysis of data points with key insights highlighted through reports, summaries and visualization. The web-based SCIS tool contains a KPI guide where the description and also the calculation of each KPI is supplied in terms of the required data.

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On the other hand, to provide assistance to include data of projects in the platform, there are several helpful guide documents in the SCIS website[2]. The monitoring guides are extensively adopted references that pave the way towards standardisation and comparability. Annex 3 provides the list of indicators proposed by each monitoring SCIS monitoring guide [1], Social Monitoring Guide [6], Self-Reporting Guide [7], Technical Monitoring Guide [8], Policy and Finance Monitoring Guide [9], Economic Monitoring Guide [10]). In total, there are 36 indicators that are focused on demonstration areas of smart city projects [11].

CityKeys

Rather than demonstrating lighthouse projects, CityKeys is a H2020 project that aims at developing a transparent performance evaluation framework including KIPs definition, guidelines for data collection, performance system prototyping, etc. Through the development of networks and collaborative platforms, CityKeys looks to identify and exploit opportunities for synergy and replicability. The EU proposal provides recommendations not only in terms of systems' performance but also with regard to the decision-making processes and development of new financing structures and business opportunities.

The monitoring framework includes 73 indicators categories under the domains of People, Planet, Prosperity, Governance and Propagation, which are evaluated at transversal aspects. The guidelines and recommendations are proposed following the 4P&G methodology (see Table 3):

Table 3: KPI guidelines resulted from CityKeys project

People	Planet	Prosperity	Governance	Propagation
Health	Energy and mitigation	Employment	Organization	Scalability
Safety	Materials. Water and land	Equity	Community involvement	Replicability
Access to (other) services	Climate resilience	Green economy	Multi-level governance	
Education	Ecosystem	Innovation		
Diversity and social cohesion		Attractiveness and competitiveness		
Quality of housing and the built environment				

[2] https://smart-cities-marketplace.ec.europa.eu/insights/publications

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CityKeys connects cities, researchers and developers along the EU and receives input from more than 40 city initiatives and performance systems. The project has developed a large set of KPIs on project and city level. The project establishes a link between the evolution of indicators measured at specific demonstration areas (project level) and those that define the performance of the entire city. The framework facilitates the evaluation of the entire city facilitating long-term evaluation criteria (what they call 'development over the years'). On the overarching approach, CityKeys facilitates a smart city assessment that includes an extensive description of the context of the project, the activities and technologies in specific projects or actuations, deployed financing and the business models, etc. In addition, it also evaluates selected impacts from a life cycle perspective, although the domains it covers are rather limited, for life cycle energy demand (embodied energy) and greenhouse gas emissions only.

ESPRESSO and Other International/National Standards

systEmic Standardisation apPRoach to Empower Smart citieS and cOmmunities (ESPRESSO) is a European initiative funded by the European commission that focuses on identifying a collection of open standards and defining conceptual frameworks for smart cities. Those should make compatible solutions coming from different sectors that have been proven to help integrate systems and enhance synergies in cities. Some of the sources of these standards were extracted from ITU and CityProtocol standards for smart cities[3]. ESPRESSO aims at developing a conceptual Smart Cities Information Framework that would alleviate the weakness and cover the gaps between already available frameworks.

ESPRESSO worked closely with international/national standards developing organizations and consortia such as: ISO, IEC, ITU, CEN, CENELEC, ETSI and IEEE. The main standards for smart city projects are designed in a way that also other stakeholders are able to apply them: the standard ITU-T FG-SSC, ISO 37151, ISO 37120, and IEEE 1888.4-2016.

Other Smart City projects (SCC1 lighthouse projects)

Besides existing M&E frameworks and international standards listed above, 16 projects[4] funded by Horizon 2020 under the "smart cities and communities" programme since 2015 were also reviewed, which are listed below in chronological order based on their project starting years.

Table 4: List of Horizon 2020 under Smart Cities and Communities since 2015

[3] https://www.itu.int/en/ITU-T/ssc/Pages/default.aspx
[4] https://ec.europa.eu/inea/en/horizon-2020/h2020-energy/projects-by-field/879

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Call ID	Call focus	Project Names	Duration	Project Website
H2020-SCC-2014-2015	Solutions integrating energy, transport, ICT sectors	RemoUrban	2015-2019	http://www.remourban.eu/
		GrowSmarter	2015-2019	https://grow-smarter.eu/home/
		Triangulum	2015-2020	https://www.triangulum-project.eu/
		Sharing Cities	2016-2020	http://www.sharingcities.eu/
		SmartEnCity	2016-2021	https://smartencity.eu/
		Replicate	2016-2021	https://replicate-project.eu/
		Smarter Together	2016-2021	https://www.smarter-together.eu/
SCC-1-2016-2017	Solutions at district scale integrating smart homes and buildings, smart grids, energy storage, electric vehicles and smart charging infrastructures, ICT platforms	RuggedISED	2016-2021	https://ruggedised.eu/home/
		MySMARTLife	2016-2021	https://www.mysmartlife.eu/
		MAtchUP	2017-2022	https://www.matchup-project.eu/
		IRIS	2017-2022	https://www.irissmartcities.eu/
		StarDust	2017-2022	https://stardustproject.eu/
LC-SC3-SCC-1-2018-2019-2020	Positive energy blocks/districts	CityxChange	2018-2023	https://cityxchange.eu/#
		Making City	2018-2023	http://makingcity.eu/
		POCITYF	2019-2024	https://pocityf.eu/
		SPARCS	2019-2024	https://www.sparcs.info/
		ATELIER	2019-2024	https://smartcity-atelier.eu/

While the domains of focus (e.g. energy, mobility, ICT, etc.) vary from one SCC project to another, almost every project covers the KPIs quantifying energy consumption and greenhouse gas emissions. There has been a shift of focus topic for the call from general “integration of smart city solutions” (e.g. energy, transport, ICT and digital platforms, buildings, E-mobility) to “positive energy blocks/districts” since 2018. Some common issues have been observed across the past and ongoing SCC projects that can be improved.

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Partial mismatch between assessed impacts and indicators for assessment

The indicators selected do not always correspond to the impact category to be assessed. For example, it was noticed that in some projects, the monitoring of air pollutants (e.g. NOx, SO2, particulate matter, etc.) reduction is used as an indicator for carbon emissions reductions, or vice versa. However, these two aspects should be usually addressed separately under air pollution and climate change respectively.

Unexpected interchangeable use of terminologies

Terminologies are sometimes unexpectedly referred interchangeably, which may cause inaccurate understanding about the definition or the scope of KPIs. For example, it is very common "carbon dioxide emissions" and "greenhouse gas emissions" were referred interchangeably in many M&E frameworks of SCC Projects, while the former is only one of the greenhouse gases.

Separate KPIs vs. the same KPI from different angles

Some defined KPIs also overlap with each other at multiple dimensions. For example, the total and normalized value of the same KPI are sometimes defined as two separate KPIs, while in fact it is the same KPI, but just normalized by different parameters (e.g. very often by floor area or number of people). The same applies for baseline values and monitored value change in comparison with baseline values.

Limited coverage of domains

There are projects that have only covered one specific domain (e.g. mobility only) without justifying their specific focus, which might be due to the evolution of theme focus required in the funding calls from year to year. In practice, many of the smart city solutions are interlinked, thus addressing specific domains may narrow the understanding of performance, making the potential of replicating the smart city solutions limited.

Lack of life cycle perspective

Although it is crucial to assess the smart city solutions from a comprehensive perspective and avoid potential burden shifting from one sector to another (e.g. from operation to construction), only 1 among the 15 SCC projects funded by the EU (i.e. SmartEnCity) has adapted the life cycle perspective in the M&E framework.

3.8 Data management for monitoring and evaluation

The data capture and reporting system of ATELIER is a flexible and well-structured system (see Figure 15) that keeps the track of every action in the project, maximizes the data quality standards fostering the reporting as meta-data, and estimates KPIs following transparent and systematic procedures.

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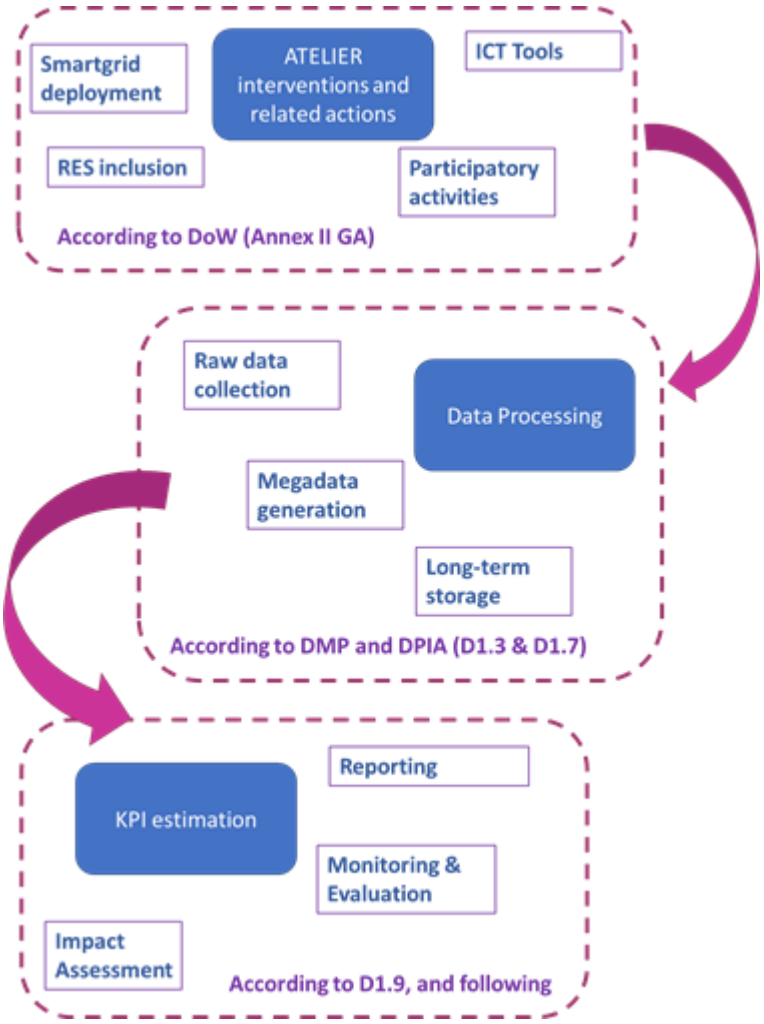

Figure 15. Data management Framework for Monitoring & Evaluation

- ATELIER defines 7 interventions at each LHC where specific actuations are planned (insertion of RES, new trading systems, smart grid deployment, participatory dynamics, establishment of regulatory frameworks, etc.). The details for each KPI are captured and refined to ensure that all parties agree on the proposed methods for monitoring and evaluation of the intervention performance.

- The data capturing, handling and storage methods follow FAIR H2020 principles and GDPR regulation (whether personal or sensitive data is gathered). ATELIER partners already count with clear methodologies and shared tools that pursue to generate 5-starts open data (https://5stardata.info/en/).

- The necessary calculations and data capturing methodology is agreed for each KPI using SCIS standards and other methods developed specifically for the project. The SCIS-SRT, Indicator database and web-based indicator observatory will be used as basic reporting tools.

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- The KPI monitoring and evaluation will be based on the details defined at KPI templates (see annex 2) which are well aligned with requirements foreseen in terms of Impact assessment on PED-scale, assessment of broader impacts /city scale and benchmarking evaluation.

3.9 Governance model for monitoring

ATELIER adopts a co-responsibility framework where a core group assists all along the process of KPI definition and monitoring to **KPI owners** and **Data Providers** (Figure 16):

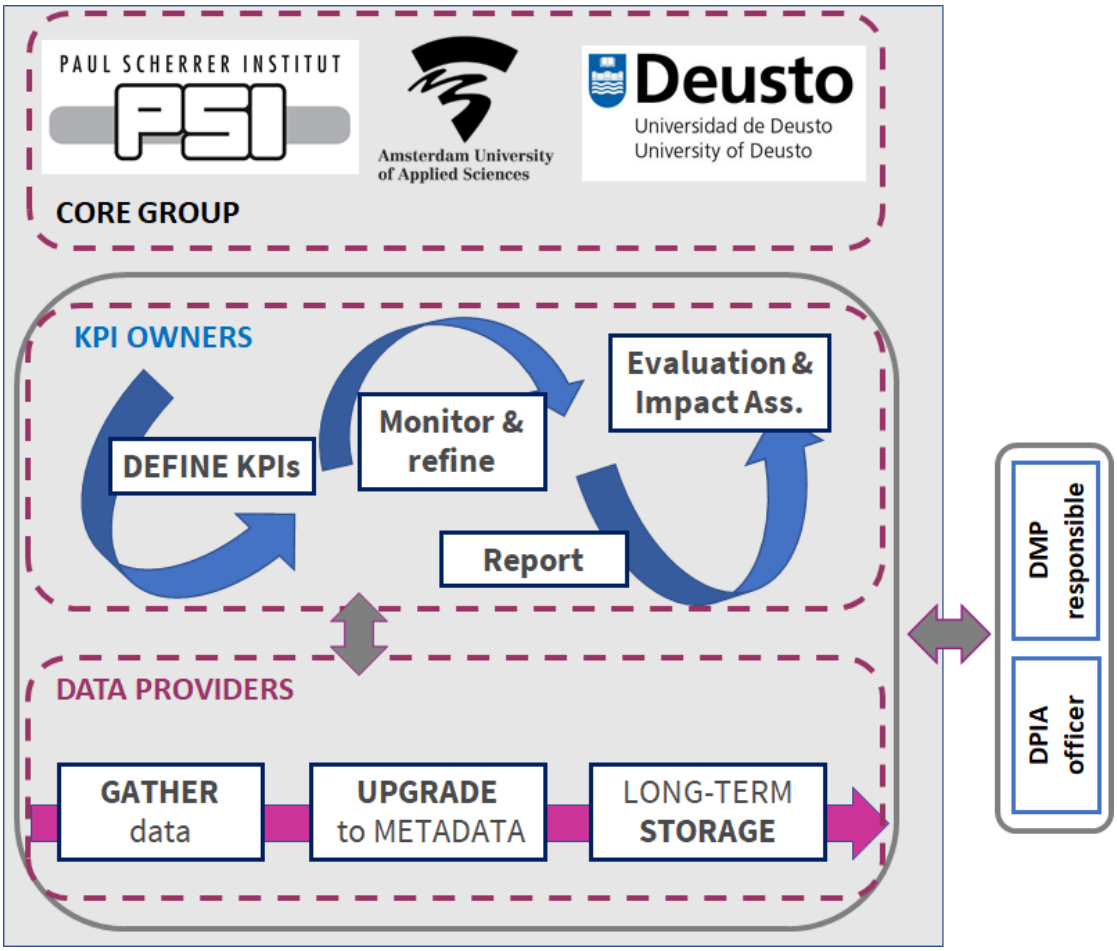

Figure 16. Governance Model for Monitoring & Evaluation

KPI owner

The KPI owner ultimately takes the lead in ensuring the proper definition of KPIs, their monitoring procedures with the specifications of the underlying data requirements as well as testing the reporting of the KPIs and refining them as needed. Therefore, the KPI owner uses the Monitoring and Evaluation framework, to ensure that intervention impacts are recorded correctly and made available for analysis. The KPI owner, together with the core group, provides the definition, description and calculation method of the KPIs according to methodologies stated in the M&E approach and KPI templates (Annex 2). KPI owner takes the leadership for monitoring according to reporting frequencies specified for each KPI, and will

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also be the main point of contact between data providers and the partner responsible for the management and update of the SCIS Self Reporting Tool (SRT). KPI owners use as basic working tools the project's indicators database and web-based observatory. During the course of the project, the KPI responsible partners are to review the accuracy and relevance of monitoring data recorded in the interventions and actuations, and make recommendations to address issues or proposals for the amendment of KPI estimation methods if needed.

Data Provider

Data Providers are parties that act as complementary partners to KPI Responsible partners. The data providers are typically specialists in their field, and are therefore well suited to provide technical support, tools and data that assist in the implementation of certain interventions. The support and insight provided contributes to the success of the intervention, as well as providing an accurate and trusted source of information that enables KPI responsible to monitor and report on the indicators they have co-designed. Data providers have been appointed and assigned to each KPI but are subject to change depending on the data needs of each individual KPI. While providing data, technical insight, and support to the KPI responsible, data providers are also responsible for the management of data that is monitored from project interventions.

Connection with the Data Management Plan Governance Model

The Data Governance Model of the Monitoring and Evaluation methodology is connected with its counterpart at the Data Management Plan where two main roles are presented: the Data Management Plan Responsible (DMPR) and the Data Protection Impact Assessment Officer (DPIAO). The DMPR endorses the responsibility of collecting, storing and sharing data according to FAIR principles and Open Data H2020 standards. The DMPR keeps ultimate responsibility of ensuring GDPR legislation with regard to any personal data generated in ATELIER.

Data providers and KPI responsibles will be generating new datasets in the context of monitoring and evaluation, and therefore endorse the already established methods as defined in the DMP and DPIA. They will be well-connected to DMPRs and DPIAOs. The four responsibilities will be clear and transparent: DMPR and DPIA are available at the shared resources while the Data providers and KPI owners will be identified and specified in the KPI templates (Annex 2). In many cases, Data providers will also be the DMPRs of the specific dataset which, however, is not necessarily the case for all KPIs and underlying data.

4. List of KPIs

In this section we provide a first list of KPIs under each evaluation domain. This first list is preliminary and is subject to changes as it will be discussed and populated together with the developers of the PEDs, with all partners related to monitoring and evaluation at different domains. Table 5 shows the list of KPIs and the related actions in the PEDs of Amsterdam and Bilbao:

Table 5: List of Horizon 2020 under Smart Cities and Communities since 2015

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KPI		Related actions by LH city	
Identifier	**Name**	**Amsterdam**	**Bilbao**
ENE_Core_01	Energy Used	32 to 40	1 to 5, 7 to 10, 16, 18, 21 to 23, 25, 27 to 30 and 41 to 44
ENE_Support_01	Electricity Used	18, 19, 20, 23, 25, 27, 31, 32, 35, 38 and 58	1 to 5, 7 to 10, 16, 18, 21 to 23, 25, 27 to 30, 41 and 42
ENE_Support_02	Heat Used	33, 36, and 39	1 to 5, 7 to 10, 16, 18, 21 to 23, 25, 27 to 30, 43 and 44
ENE_Core_02	Energy Savings	32 to 40	1 to 5, 7 to 10, 16, 18, 21 to 23, 25, and 27 to 30
ENE_Core_03	Renewable energy production	12 to 18, 31 to 33 and 41 to 44	5 to 22
ENE_Support_03	Renewable electricity production	5 to 13 and 21	13,14,16,18, and 31 to 33
ENE_Support_04	Renewable thermal energy production	1 to 4	12 to 15
ENE_Core_04	Exported energy outside the PED	1 to 22 and 32 to 40	1 to 5, 7 to 10, 12 to 16, 18, 21 to 23, 25, 27 to 30 and 41 to 44
ENE_Core_08	Exported electricity outside the PED	5 to 21 and 32, 35, 38	1 to 5, 7 to 10, 13, 14, 16, 18, 21 to 23, 25, 27 to 33, 41 and 42
ENE_Core_09	Exported thermal energy outside the PED	1 to 4, 22, and 33, 36, 39	1 to 5, 7 to 10, 12 to 18, 21 to 23, 25, 27 to 30, 43 and 44
ENE_Core_10	Exported energy outside the PED at peak time	5 to 21 and 32, 35, 38	1 to 5, 7 to 10, 13, 14, 16, 18, 21 to 23, 25, 27 to 33, 41 and 42
ENE_Core_15	Percentage of peak load reduction	24, 26, 28, 29, 30, 34, 37, 40, and 44	44 and 46
ENE_Core_16	Energy storage capacity	14 to 17, 18 to 20, 22, and 49	14 to 17
EC_Core_01	Simple Payback period	49	45, 46 and 52
EC_Core_02	Total investments	49	45, 46 and 52

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EC_Core_03	Total annual costs	49	45, 46 and 52
EC_Support_05	Average CO2 abatement cost	49	45 to 48 and 52
EC_Support_06	Percentage of local energy resources traded locally	49 and 51	29 and 44 to 46
EC_Core_07	Consumers engagement in local energy trading and DSM	49 and 51	29 and 44 to 46
ENV_Core_01	Energy-related greenhouse gas emissions	1, 2, 3, 5, 7, 8, 9, 12, 14, 17, 21, 22, 23, 25, and 30 to 47	21, 32 to 41
ENV_Core_02	Energy-related greenhouse gas emissions reduction	1, 2, 3, 5, 7, 8, 9, 12, 14, 17, 21, 22, 23, 25, and 30 to 47	21, 32 to 41
ENV_Core_03	Life cycle greenhouse gas emissions	all	all
ENV_Core_04	Life cycle primary energy demand (non-renewable)	all	all
ENV_Core_05	Life cycle total environmental footprint	all	all
ENV_Core_06	Particulate matter emissions (PM 2.5) reduction onsite	19, 20, 45 and 46	18 to 20
ENV_Core_07	Nitrogen oxides emissions (NOx) reduction onsite	12, 15, 17, 19, 20, and 43 to 47	1 to 4 and 18 to 20
ENV_Support_01	Water consumption onsite	14	n.a
ENV_Support_02	Received noise by building users	12, 15, 19, 20, and 45 to 47	56 and 57
ENV_Support_03	Outdoor noise (hourly)	19, 20 ,45 and 46	31
ENV_Support_04	Indoor humidity (hourly)	4, 10, 28 and 29	41 to 43, 56 and 57
ENV_Support_05	Indoor Temperature (hourly)	1, 2, 7, 16, 18, 21, 22, 25 and 30	41 to 43, 56 and 57
ENV_Support_06	Outdoor Temperature (hourly)	n.a	31
EMOB_Core_01	Annual energy delivered by charging infrastructure	19, 20, 35, 36, 37, 41, 42 and 45	18 to 20, 32, 35, and 38

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EMOB_Core_02	Relative modal shift from fossil-fuel vehicles to electric mobility	19, 20, 45 and 46	41 to 43
EMOB_Core_03	Relative share/contribution of Vehicle to Grid (V2G) to the total energy system performance	19, 20, 45 and 46	18 to 20, 32, 35, and 38
EMOB_Core_04	Relative share of EV demand covered by local RES	31 to 33, 34, 35, 45, 46 and 47	18 to 20, 32, 35, and 38
SOC_Core_01	Improvement of quality of life for the PED inhabitants	cross-cutting	cross-cutting
SOC_Core_02	Progress towards energy citizenship	cross-cutting	cross-cutting
SOC_Core_03	Impact on habits and lifestyle towards sustainability	cross-cutting	cross-cutting
SOC_Core_04	Feeling the pulse - monitoring citizen engagement	cross-cutting	cross-cutting

4.1 Energy including energy efficiency, renewable energy and energy flexibility

ATELIER objectives and methodology

The main objective of the ATELIER project is to create PEDs in Amsterdam and Bilbao replicable to the fellow cities. The design of PEDs combines the following energy aspects: renewable energy production, increased energy efficiency and flexibility, energy autonomy and zero direct emissions of non-biogenic CO2. Thus, the KPI framework on energy is built to allow the monitoring and evaluation of these different themes.

The goal of an increase of renewable energy production is to provide sources of energy with reduced environmental footprints that will surpass the energy consumption within the district allowing to achieve the sustainability and positivity ambitions of the project. The increase in energy efficiency is complementary to renewable energy production aspects as it facilitates the achievement of net energy surplus by reducing energy consumption within the district.

The main roles and functions of PEDs regarding energy flexibility are to actively contribute to the resilience and balancing of the regional energy system with the optimal benefit for the regional energy system in mind. Also, PEDs should manage any interactions between the urban district/neighbourhood and the regional energy system such as to enable carbon neutrality and 100% renewable energy in the local consumption and an additional surplus of renewable energy over the years[5]:

An energy system is flexible if it can cost-effectively, reliably and across all time scales meet the peak loads and peak net loads, and avoid loss of load. To this purpose, the system maintains the balance of supply and demand and has sufficient storage capacity (both

[5] https://jpi-urbaneurope.eu/ped/

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electricity storage and, through sector coupling, renewable heat and gas) to balance periods of high variable renewable energy generation and periods of high demand but low generation [12].

KPIs related to the economic impact and business development in the area of energy system flexibility and local/peer-to-peer energy and flexibility trading are presented under the energy domain.

Each energy KPI wasidentified through the general selection and development process and the scanning of KPIs listed in previous SSC projects and in the SCIS documentation. Several of these indicators are adapted to the context of the project. This list is then complemented by additional indicators to capture interventions specific to ATELIER.

Amsterdam PED demo: main interventions

The Positive Energy District in Amsterdam will be developed in different locations in the Buiksloterham (as a virtual PED).

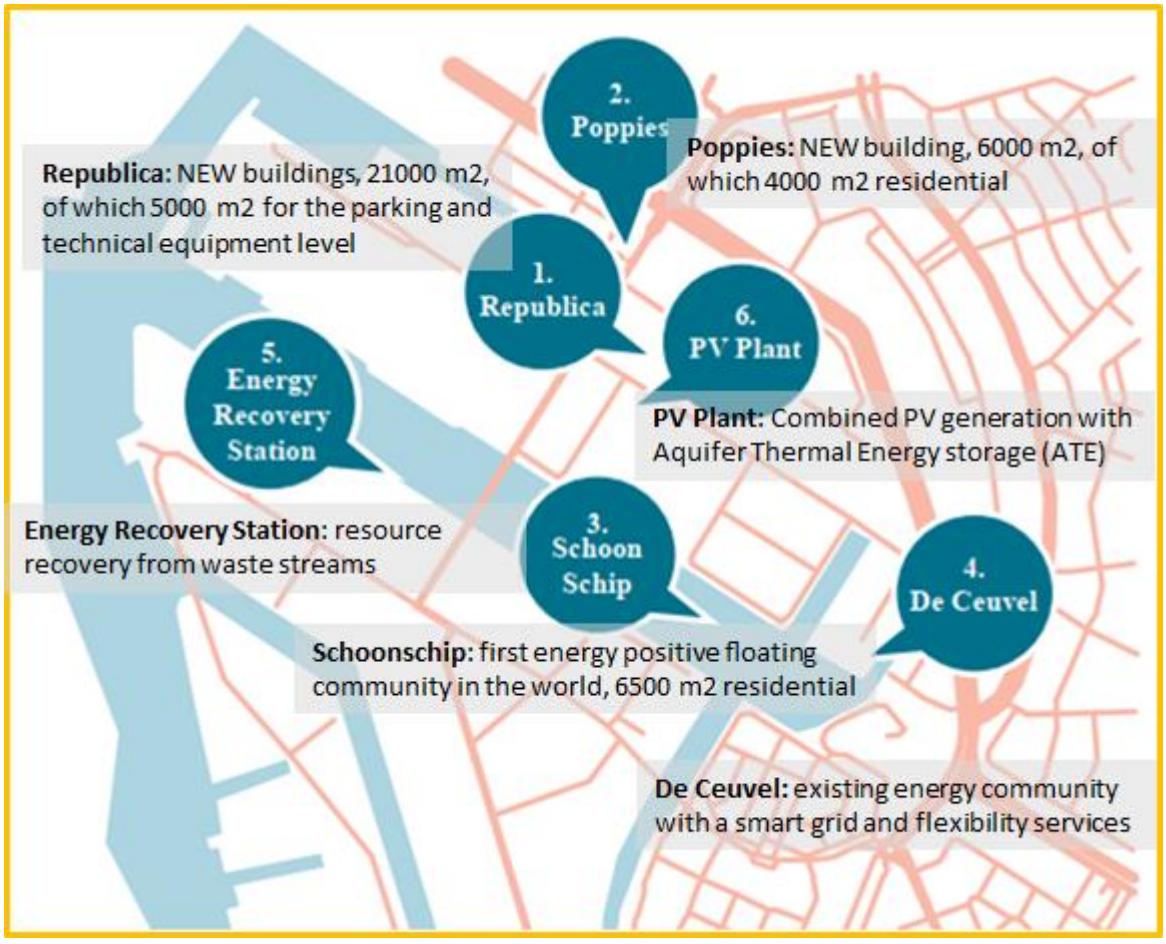

Figure 17. Positive Energy District in Amsterdam

The PED proposed in Buiksloterham consists of a number of very ambitious building groups (in total being 28500 m2 GFA) Two of those are new built in the project. These are Republica

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and Poppies (total of 22000 m2). The third is Schoonschip, to be finished in 2019. This building group is added because of the connection to the energy recovery station, the implementation of the smart grid and the participation in the Buiksloterham Energy Community, all elements of the project. The fourth is De Ceuvel, an existing energy community with a smart grid, participating in the energy trading activities of the project. The energy recovery station and the local PV plant are situated on the other two locations. The building groups are of a mixed nature, a combination of tertiary buildings (approximately 12600 m2) with residential (approximately 15900 m2). These buildings are combined in the district with a station for local (energy and resource) recovery of sewage waste streams and local renewable energy generation. The proposed district in this proposal is the blueprint for the development of the entire area.

The ambition for this district is to make it an area with limited private transport by cars and to foster the electro-mobility. The building developments include smart grids that enable energy exchange within the district (for diminishing grid load and to promote self-consumption of RES). This also leads to the possibility of energy trading and managing energy production and consumption between the various sites. The flexible energy management system is facilitated by a special derogation from specific Dutch electricity regulation that makes possible for cooperatives and associations of property owners to deviate from the general law. Another facilitating element is the energy cooperative PEK Ecostroom that participates the Buiksloterham Energy Community.

Bilbao PED demo: main interventions

The positive energy district will be developed in three locations at the Zorrotzaurre island, namely the NORTH, CENTRE and SOUTH. The three areas are connected via a geo-exchange loop which is a system that will use geothermal and hydrothermal renewable energy to cover the thermal demand of the PED locations and to export the surplus to the rest of the island and, eventually, outside the island.

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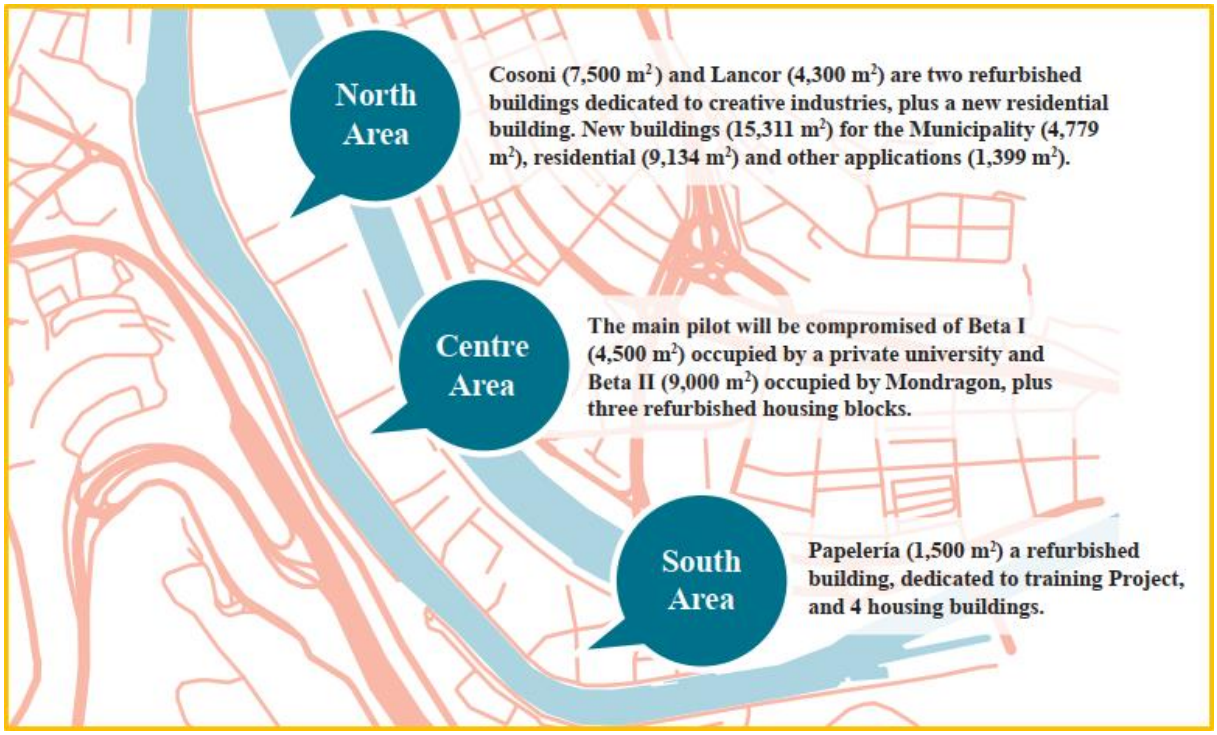

Figure 18. Positive Energy District in Bilbao

In addition to the connection to the geothermal network (intervention IV) and the smart grid (intervention V), the district counts with increased capacity of electro-mobility (intervention VI), energy storage capacity, and smart furniture and lighting (intervention VII).

In the NORTH (intervention I), CENTRE (intervention II) and SOUTH (intervention III) areas of the PED demo, a new generation of smart meters for monitoring and protection will be implemented. Demand response solutions and energy community self-generation sharing will be set up and validated. The objective is to continue developing functionalities that provide value to the client, including the flexibility for the consumer to provide services, mainly in terms of active demand management.

Energy flexibility will be possible through the deployment of smart metering devices, smart Building Energy Management Systems (smart BEMS) and an overarching Energy Management Systems that will aggregate BEMSs and other smart district consumptions (public services, storage systems, heat pumps, EVs' operators, etc.). The Energy Management System works as a 'Energy Trading Coordinator' providing prosumers and energy communities an active demand response approach that effectively coordinate and deploy local resources in order to balance energy supplies and demands, at the same time that would activate different flexibility business models.

New substations with control capability that will incorporate new functionalities necessary to manage a low voltage network with a high penetration of flexible distributed resources that can provide services to the electricity network will be implemented. The intelligent secondary substation will introduce supervisory architecture and advanced control for network optimization (reduction of losses and saturation level) by maneuvering the network elements and allowing the flexibility and services of customers.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 864374.

Indicators proposed for energy performance assessment

ENE_Core_01 - Energy Use

The KPI energy use tracks the final net energy consumption in terms of primary energy within the territory boundary of the PED by the end users or systems to provide and operate the different energy services. The calculation of final net energy use is based on the monitored or estimated data and it considers different energy carriers (i.e. electricity, natural gas, biogas, etc.) which are converted to MWh of equivalent primary energy.

ENE_Support_01 - Electricity Use

The KPI electricity use tracks the final electricity use within the territory boundary of the PED by the end users or systems to provide and operate the different electricity-based services. It is based on the monitored or estimated data expressed in MWh.

ENE_Support_02 - Thermal Energy Need

The KPI thermal energy need tracks the final net thermal energy needs for space heating, space cooling and hot water within the territory boundary of the PED by the end users or systems to provide and operate the different heat services. It is based on the monitored or estimated data expressed in MWh.

ENE_Core_02 - Energy savings

This KPI determines the reduction of the final net energy use (ENE_Core_01) of the PED, calculated in terms of primary energy, to reach the same services (e.g. comfort levels) after the interventions, taking as reference the energy use from the baseline. It considers all forms of energy and is expressed in MWh of saved energy. The baseline is determined using the Dutch EPC system in Amsterdam and the Building Technical Code (BOE-A-2006-5515, Real Decreto 314/2006, 17th of March) in Spain. Reduced energy use (or energy savings) generates cost savings, facilitates the achievement of a net energy export and improves the overall environmental footprint of the PED.

ENE_Core_03 - Renewable Energy

This KPI monitors the total renewable energy generated within the boundaries of the PED. It accounts for energy from sources that are not depleted by extractions, such as solar energy (thermal and photovoltaic), wind, water power, and renewed biomass.

ENE_Support_03 - Renewable electricity production

This KPI monitors the amount of electrical energy derived from renewable sources within the boundaries of the PED. Energy from renewable sources means energy from sources that are not depleted by extractions, such as solar energy (thermal and photovoltaic), wind, water power, renewed biomass.

ENE_Support_04 - Renewable thermal energy production

This KPI monitors the amount of thermal energy derived from renewable sources within the boundaries of the PED. Energy from renewable sources means energy from sources that are not depleted by extractions, such as solar energy (thermal and photovoltaic), wind, water power, renewed biomass.

ENE_Core_04 - Exported Energy

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 864374.

The exported energy KPI tracks the surplus renewable energy delivered outside the PED over a period of time. It combines both thermal and electrical energy by comparing the final energy needs and renewable energy generation within the PED. Aggregation of different energy carriers will be based on primary energy equivalents. The project goal is to reach an energy surplus enabling entire districts to contribute to urban sustainability goals. This KPI is expressed in three different ways:

- As an absolute number representing the total exported renewable energy in MWh.
- As a percentage representing the total net energy needs covered by local renewable energy systems. This determines the degree to which the on-site renewable energy generation is sufficient to meet the final energy needs of the PEDs.
- As a period of time in hourly resolution determining the number of hours during which there is a surplus of renewable energy production.

ENE_Support_05 - Exported electricity

The KPI exported electricity monitors the surplus electricity delivered outside the PED over a period of time determined, by comparing the final electricity use and the locally produced renewable electricity production. This KPI is expressed in three different ways:

- As an absolute number representing the total electricity exported in MWh.
- As a percentage representing the total net energy needs covered by locally produced renewable electricity. This determines the degree to which the on-site electricity generation is sufficient to meet the final electricity needs.
- As a period of time, in hourly resolution, determining the number of hours during which there is a surplus of renewable electricity production.

ENE_Support_06 - Exported thermal energy

The KPI exported thermal energy monitors the surplus renewable thermal energy delivered outside the PED over a period of time determined, by comparing the thermal energy needs and the renewable thermal energy production. This KPI is expressed in three different way:

- As an absolute number representing the total thermal energy exported in MWh;
- As a percentage representing the total net energy needs covered by locally produced renewable thermal energy. This determines the degree to which the on-site thermal generation is sufficient to meet the final thermal energy needs.
- As a period of time, in hourly resolution, determining the number of hours during which there is a surplus of renewable thermal energy production.

ENE_Support_07 - Energy exported outside the PED at peak time

The KPI energy exported out of the PED at peak time, calculates the net surplus renewable energy delivered outside the PED boundary during the daily peak hours. The daily peak hour periods are defined by the distribution system operators in the city of Amsterdam and Bilbao. PEDs should not only aim to achieve an annual net surplus of renewable energy, but these surpluses should also be managed to reduce the stress on the networks by contributing positively or be self-sufficient in periods of peak demand. This KPI is expressed in three different ways:

- As an absolute number representing the total renewable energy exported in MWh.

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- As a percentage representing the total net energy needs covered by local renewable energy systems. This determines the degree to which the on-site renewable energy generation is sufficient to meet the final energy needs of the PEDs.
- As a period of time, in hourly resolution, determining the number of hours during which there is a surplus of renewable energy production.

ENE_Support_08 Percentage of peak load reduction of PED

Comparing the peak energy demand before the aggregator implementation (baseline) with the peak demand after the aggregator implementation (per final consumer, per feeder, per network). E.g. Peak load is the maximum power consumption of a building or a group of buildings to provide certain comfort levels. With the correct application of ICT systems, the peak load could be reduced and therefore the dimension of the supply system. In SCIS, the indicator is used to analyse the maximum power demand of a system in comparison with the average power.

Percentage of peak load reduction is calculated as the comparison of peak energy demand before the application of ICT interventions to the peak energy demand after the application of ICT interventions. The peak load after ICT interventions is divided by the peak load at BAU scenarios, from which the percentage load reduction is derived. Seasonal variations are to be considered. (Source: SCIS [1], CityxChange [3])

The baseline is zero as in current practice the lack of flexibility does not allow peak reduction/shifting. The target is still to be set for each PED demonstration but should be a reduction that will have a significant impact, in particular the business case for flexibility measures. The impact of the specific measures on the peak load could be assessed through the energy management system by comparing the load profile with and without active measures. The methodology will be further discussed with the EMS operator.

ENE_Core_5 Energy storage capacity installed in PED

This KPI measures the local storage capacity for energy balancing within the PEDs. The KPI is calculated as the sum of installed storage capacity which is an important parameter in relation to the energy load and production. It is a costly PED innovation and its dimensions need to be optimized in order to both achieve the flexibility targets and reduce investment costs (source SCIS [1], CityxChange [3]).

The baseline is zero, as in common practice no storage is included in new buildings, because the current business case is not feasible. The targets are specified in the PED design documents.

4.2 Life cycle and onsite environmental impacts

ATELIER objectives and methodology

The primary objective in ATELIER is to achieve positive energy districts, which means in the average annual energy balance, there are no net needs for external grid electricity or fossil

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fuels, thus the associated environmental impacts of producing these energies are also avoided. Measures that help to reduce the energy demand such as improved insulation in the building envelope, green roof, triple glazing, waste-to-energy etc. are implemented, and all these corresponding energy-related greenhouse gas emissions as well as the reduction are quantified.

Besides energy-related greenhouse gas emissions, environmental impacts are evaluated from the life cycle perspective. For life cycle environmental impacts, the KPIs of this domain include not only climate change and primary energy (which are the two most common indicators when life cycle assessment is applied to evaluate sustainable buildings and districts), but also overall environmental footprint, which considers a broader range of environmental impacts on ecosystem, human health and resources. The system boundary of life cycle assessments is illustrated below.

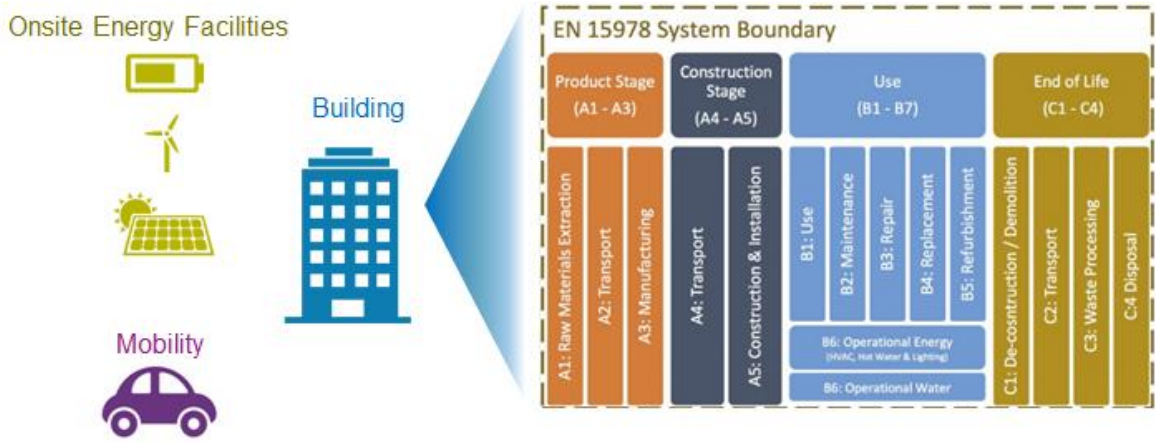

Figure 19. System boundary of life cycle assessment of an urban district

In addition to the life cycle environmental impacts, onsite impacts on human health, water resource consumption, and the well-being of residents/building users are included. These include selected air pollutants emissions (i.e. particulate matter, nitrogen oxides), water consumption, and indicators that are related to user comfort or experience in the environment, such as received noise, temperature and humidity.

The detailed list of KPIs, their definitions and approach for defining baseline are listed below. For KPIs evaluated using life cycle assessment, baseline values are not provided due to lack of previous benchmark values based on the life cycle assessment of districts. Baseline values are also not provided for the KPIs monitored or surveyed onsite (i.e. temperature, humidity, noise), as these KPIs are either monitored dynamically or surveyed based on user experience, thus it is difficult to define appropriate baseline values for them, and they are included more for the purpose of monitoring and understanding the user experience.

All the interventions implemented in ATELIER will result in environmental impacts, either indirectly or directly. The list of KPIs considered in the Life cycle and onsite environmental impacts domain can be split into three subcategories: 1) energy-related greenhouse gas

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emissions, 2) life cycle environmental impacts caused by the consumption of products and services provided within the PED, and 3) direct impacts or user experience about the environment onsite (e.g. air pollutants, temperature, humidity, noise) as a result of implemented interventions and actions.

For subcategory 1), the energy-related greenhouse gas emissions can be influenced by both energy efficiency measures, which reduce energy demand, and renewable energy supplies, which have different environmental impacts per unit of energy supply in comparison with conventional fossil energy supplies. For subcategory 2), because the KPIs are evaluated from the life cycle perspective, any consumption of materials or provision of services within the PED will result in environmental impacts either upstream or onsite. This means that all the interventions and actions can be regarded as interventions on the environment, and thus are not listed here in details.

Indicators proposed for environmental assessment

ENV_Core_01 Energy-related greenhouse gas emissions

This KPI quantifies the greenhouse gases emissions related to operational energy consumption within the PED. The baseline value for this KPI should be obtained from the simulations of an equivalent baseline system and should not exceed normalized GHG emissions per capita listed for the Netherlands and Spain[6].

ENV_Core_02 Energy-related greenhouse gas emissions reduction

The greenhouse gas emissions reduction assesses the greenhouse gas emissions savings resulting from interventions in PED. The indicator expresses the difference of situation before and after the development of the project or, in case of new developments, to a state-of-the-art or business-as-usual option. The baseline value for this KPI is assumed to be zero reductions of energy-related GHG emissions reduction.

ENV_Core_03 Life cycle greenhouse gas emissions

This KPI will quantify the life cycle infrared radiative forcing increase due to the emissions of greenhouse gases caused by PED, due to consumption of materials and provision of services within PEDs. This indicator will be quantified using life cycle assessment.

ENV_Core_04 Life cycle primary energy demand (non-renewable)

Life cycle non-renewable primary energy demand due to consumption of products and service provided within the PED. This is a result from the life cycle assessment.

ENV_Core_05 Life cycle total environmental footprint

Environmental impacts are more than climate change. This indicator will consider a broader range of environmental impacts on ecosystem, human health and resources into account, and quantify a total environmental impact score based on various life cycle environmental impacts, including 16 impact categories: life cycle greenhouse gas

[6] Normalized GHG emissions per capita by EU country: https://ec.europa.eu/eurostat/tgm/table.do?tab=table&init=1&language=en&pcode=t2020_rd300&plugin=1

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emissions, ozone layer depletion, human toxicity, fine particulate matter, ionizing radiation, photochemical ozone formation, acidification, terrestrial-, freshwater- and marine-eutrophication, freshwater ecotoxicity, land use, water use as well as fossil, mineral and metal resources. Since the robustness for quantifying different environmental impacts vary, and priorities of dealing with different environmental impacts can be also different among regions, this indicator will take both into account, and apply consensus methods and weighting factors according to the report "Development of a weighting approach for the Environmental Footprint" published in 2018 by the Joint Research Centre (JRC) and the European Commission [13] so that a total environmental footprint score can be calculated and support policy and decision making as an additional reference to life cycle environmental impacts affecting climate change and primary energy demand. Although only the total environmental footprint is included as one of the core KPIs for simplicity in supporting decision making, absolute environmental impact values are reported for each individual impact as additional reference for more detailed understanding and benchmarking.

ENV_Core_06 Particulate matter emissions (PM 2.5) reduction onsite

Particulate matter emission reduction based on the calculation considering vehicle types and fuel properties before and after project interventions. PM 2.5 is selected while the other air pollutants are excluded because according to the historic monitored air quality data near the demonstration sites in the lighthouse cities[7], PM 2.5 is the only air pollutant that is of potential concern while others are not. When this KPI is adapted in replication, specific selection of air pollutants should be adjusted considering local context and priorities.

ENV_Core_07 Nitrogen oxides emissions (NOx) reduction onsite

Nitrogen oxides (NOx) emission reduction based on the calculation considering vehicle types and fuel properties before and after project interventions. When this KPI is adapted in replication, specific selection of air pollutants should be adjusted considering local context.

ENV_Support_01 Water consumption onsite

Water consumption can be reduced due to water conservation measures (e.g. vacuum toilet in Amsterdam). This KPI will measure the reduced water consumption. The baseline value will be defined based on statistics for residential drinking water consumption in European countries in 2017[8].This KPI is only applicable for the demonstration PED in Amsterdam due to the linked action in water conservation.

ENV_Support_02 Received noise by building users

Noise is an important indicator related to human health and the quality of life. Implementation of heat pumps and electric vehicles will have influence on the onsite noise levels, while on the

[7] Bilbao: https://aqicn.org/city/spain/pais-vasco/bilbao/mazarredo/,
Amsterdam: https://aqicn.org/city/netherland/amsterdam/van-diemenstraat/

[8] http://www.eureau.org/resources/publications/1460-eureau-data-report-2017-1/file

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other hand, good sound insulation material will reduce the noise received by the users of the buildings.

ENV_Support_03 Outdoor noise (hourly)

Noise is an important indicator related to human health and the quality of life. Implementation of heat pumps and electric vehicles will have influence on the onsite noise levels, which will influence the experience of the residents and users in the PEDs. The baseline values will be defined based on noise statistics in the LHCs[9].

ENV_Support_04 Indoor humidity (hourly)

Indoor humidity is a key indicator that reflects the comfort of residents and building users in the new and retrofitted building. This indicator will be measured onsite at hourly-timestep.

ENV_Support_05 Indoor Temperature (hourly)

There is a range of indoor temperature in which residents and building users feel comfortable with, thus it is important to measure the indoor temperature to understand how positive-energy design would influence the user experience in terms of temperature. This indicator will be measured onsite at hourly-timestep.

ENV_Support_06 Outdoor Temperature (hourly)

Outdoor temperature would determine the energy required to heat/cool the building in order to maintain a reasonable indoor temperature, which is key for user comfort within the buildings. Good design of public space (e.g. with greenery coverage) will also reduce the urban heat island effect and outdoor temperature in summer. This indicator will be measured onsite at hourly-timestep.

4.3 Economic impact and business development

ATELIER objectives and methodology

The large-scale deployment of PEDs requires the development of sustainable business models that consider the whole process of building, operating and maintaining PEDs.

There is no predefined business model for the successful development of a PED. Instead, a combination of different business models are to be defined. The business strategies will be led by the stakeholder involved, which in general terms include cities, real estate developers, building owners, providers of innovative technologies, energy infrastructure operators, cooperatives of energy users, etc. These new models will imply arrangements and contracts that tackle the main pillars of PED energy systems: energy efficiency, renewable energy production, ICT penetration, energy system flexibility, electric mobility, etc.

[9] Amsterdam Noise map 2018: https://maps.amsterdam.nl/geluid/?LANG=nl
Bilbao Noise Map 2017: https://www.bilbao.eus/cs/Satellite?cid=1279175993929&language=en&pagename=Bilbaonet%2FPage%2FBIO_contenidoFinal

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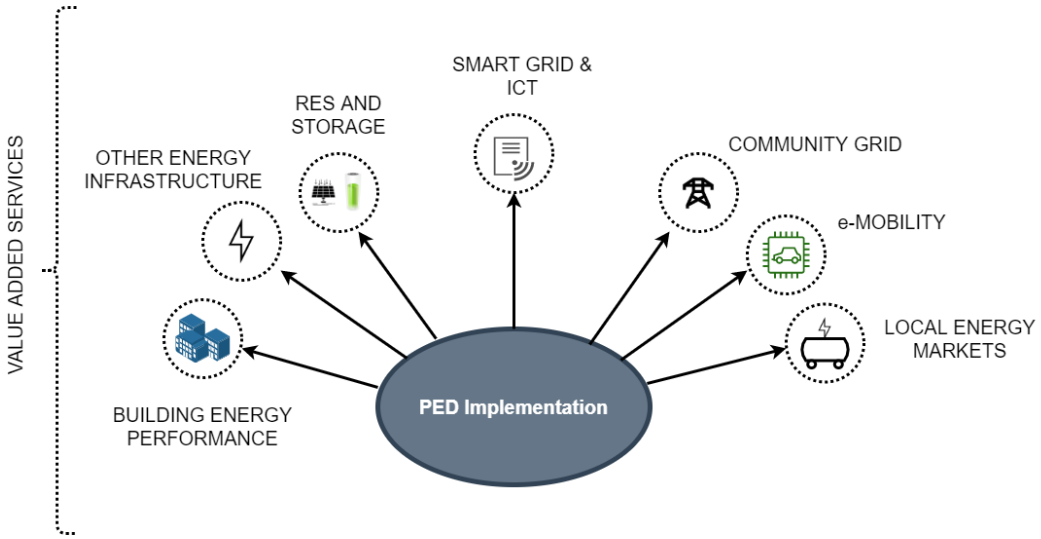

Figure 20. Overview of PED investment interventions to be assessed by economic KPIs

These new business models will be facilitated by specific actions:

- In Amsterdam, a local energy market platform will use a blockchain-based trading token enabling the local energy communities, citizens, and businesses to trade energy with each other and the wholesale energy and balancing markets. The entire PED and other interested participants in the Buiksloterham district will be invited to participate to get connected to the local energy market platform.

- In Zorrotzaurre, an Energy Management System will allow dynamic management of energy consumptions and demands making use of flexible energy system services that will be inter-connected and linked to flexible business models for:

  - ✔ Positive exploitation of services around thermal energy supply that uses geothermal energy in a network of interconnected rings.
  - ✔ Services around flexibility services and demand response for building managers, energy communities, end-users and residents, etc.
  - ✔ Surplus production of low (anergy) and the corresponding ancillary services for exploiting outside the PED or high temperature to the users of the buildings.
  - ✔ Other services related to EVs, interests of energy community associations, activation and empowerment of prosumers, etc.

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Indicators proposed for economic impact and business development

EC_CORE_01 - Simple Payback Period

This KPI tracks the ability to develop efficient Sustainable Investment models in order to determine the degree to which return on investment has been shortened using the simple payback method, using real (non-discounted) values for future monies. The payback period is the time it takes to cover investment costs. It can be calculated from the number of years elapsed between the initial investment and the time at which cumulative savings offset the investment. Simple payback takes real (non-discounted) values for future monies. Discounted payback uses present values. Payback in general ignores all costs and savings that occur after payback has been reached. Payback period is usually considered as an additional criterion to assess the investment, especially to assess the risks. Investments with a short payback period are considered safer than those with a longer payback period.

EC_CORE_02 - Total Investments

An investment is defined as an asset or item that is purchased or implemented with the aim to generate payments or savings over time. The investment in a newly constructed system is defined as cumulated payments until the initial operation of the system. The investment in the refurbishment of an existing system is defined as cumulated payments until the initial operation of the system after the refurbishment. (Grants are not subtracted).

EC_CORE_03 - Total annual costs

The total annual costs are defined as the sum of capital-related annual costs (e.g. interests and repairs caused by the investment), requirement-related costs (e.g. power costs), operation related costs (e.g. costs of using the installation, i.e. maintenance) and other costs (e.g. insurance). These costs (can) vary for each year.

- Capital related costs encompass depreciation, interests and repairs caused by the investment.
- Requirement-related costs include power costs, auxiliary power costs, fuel costs, and costs for operating resources and in some cases external costs.
- Operation-related costs include among other things the costs of using the installation and costs of servicing and inspection.
- Other costs include costs of insurance, general output, uncollected taxes etc.

The total annual costs are related to the considered interval of time (year). To make different objects comparable the same types of costs have to be included in the calculation.

EC_SUPPORT_01 Average CO2 abatement cost

The specific KPI estimates the costs in euros per ton of CO2 saved per year. This KPI can be estimated by capitalizing on information already available in other KPIs: carbon dioxide emission reduction (ENV_CORE_02) and total annual costs (EC_CORE_03). The calculation will incorporate emissions saved over the expected lifetime of the interventions in order to calculate total average abatement costs.

EC_SUPPORT_02 Percentage of local energy resources traded locally

The amount of local RES traded in relation to the total amount produced is an indication of the attractiveness of the PED scheme. This KPIs assumes that the local energy trading will provide

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a financial incentive to local RES, because local buyers will pay a surplus. It also validates the assumptions on willingness to trade and pay.

The baseline is zero, because local energy trading is currently in an experimental phase. The target is 100%, assuming that local RES cannot cover the full demand. The monitoring is based on data from the Local Trading Platform (Amsterdam) and the Energy Management System (Bilbao)

EC_CORE_04 Consumer engagement in local energy and flexibility trading and Demand Side Management (DSM)

This KPI assesses the level of interest across all inhabitants in a PED in the options for active involvement in the energy supply and demand. This included energy and flexibility trading, as well as individual demand-side management (supported by the user interfaces). The KPI provides more qualitative information on the engagement of consumers in each specific option.

The baseline is zero. Local energy and flexibility trading is still in its infancy and in a pilot phase. Also, in new constructions, the options for DSM available to inhabitants are very limited. The target is that the level of engagement for each option is high enough to ensure a significant impact on the energy performance and the viability of the business cases. The target will be set for each specific intervention for each demo.

The indicator will be expressed as percentage of total inhabitants, differentiated to population categories (demographics, attitude, income). This will allow a prediction to the engagement levels in upscaled and replicated PEDs.

The baseline is zero, as, currently, the residents in a building have no opportunities for local energy and flexibility trading and for demand-side management. The target is still to be set but should be a level of participation that is necessary to have a significant impact on the energy impacts of these interventions. The target will be different for each demonstration.

The monitoring is based on the number of contracts between end-users and the trading and flexibility operator/aggregator, the trading volume and measurement of the DSM actions through the EMS.

4.4 Mobility services and charging infrastructure

Objectives and interventions

Positive Energy Districts (PEDs) require interaction and integration between buildings, the users and the regional energy, mobility and ICT system. A PED couples the design of urban spaces, sustainable production and consumption, and mobility to reduce energy use and greenhouse gas emissions and to create added value and incentives for the consumers. In ATELIER, PEDs facilitate the increased EV charging capability and ensure that the impact of EVs on the distribution will be minimised by using local RES where possible.

In the two PED demos in Amsterdam and Bilbao, ATELIER will showcase innovative solutions that integrate buildings with smart mobility and energy technologies to create a surplus of energy and balance the local energy system. The cross city learning activities and collective sharing of experiences in the demonstrators are collected based on data that allow the impact

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assessment of e-mobility on the electricity grid. The e-mobility interventions will increase the uptake of e-mobility, reduce CO2 emissions, improve local air quality, contribute to balancing the grid and reduce car ownership in the area.

Amsterdam PED demo: mobility interventions

The Amsterdam PED demo will integrate an e-mobility hub for 15 to 20 electric cars, as well as facilities for charging electric bikes and specific urban vehicles. The electromobility hub, apart from providing clean transport to the users, serves as an opportunity to familiarize citizens with electromobility and attempts to create behavioral change in favor of shared and clean mobility: Mobility As A Service (MAAS). The new EV charging points in the PED in Amsterdam are integrated with the local smart grid management system. In total, there will be more than 70 EV charging points in both the public and private spaces within the Amsterdam demonstrator (intervention VI; action 19-20 and 45-46).

This allows the demonstration and testing of the interplay of the PED with e-mobility and battery buffering, exploring opportunities for smart charging, vehicle2grid, local buffering (of renewable energy), analyse impacts of fluctuations (on different time-scales) and explore effects of the changing EV landscape (battery size, EV market penetration). The impact on the grid will be analysed including that of standard charging and smart charging.

Bilbao PED demo: mobility interventions

The whole Zorrotzaurre Island is intended to become a zero-emission mobility hub, including 100% electric public transportation. The island of Zorrotzaurre will be accessible just for zero-emissions mobility (Intervention VI; actions 18-20).

In the demo, new e-mobility concepts will be integrated within the demonstration area running in parallel with the progressive elimination of surface parking areas for non- electric vehicles affecting both public and private electric transport.

The PED demonstrator integrates smart-charging for E-vehicles (cars, bicycles and electric busses (300kW) combined with local storage (300kWh) to reduce the impact of electric busses charging on the distribution grid. The demo PED will implement a wide range of smart mobility services, from a smart public charging hub for cars and bikes, to E-bus charging connections.

The following charging infrastructure is planned in the demo area:

- Fast EV chargers in the south area recharge hub. 2 double fast EV chargers of 50 kw each one will be installed in the south area public recharge hub. The smart public recharge hub is to cover all the e-mobility needs of the Zorrotzaurre area.
- Medium power EV chargers in the south area recharge hub. 2 double medium power EV chargers of 22 kw each one will be installed in the south area public recharge hub.
- EV charger for electric boat's batteries in the south area. One 7,2 kw charging station for alternatively charging the Electric Boat's two batteries will be installed.

In the PED in Bilbao, two double fast EV chargers and two medium chargers are installed (and one charger for electric boats). The smart charging points are connected to the PED local smart grid. Impact of EV on the smart grid and on the PED as well as grid management approaches will be tested.

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Indicators proposed for electro-mobility services and charging infrastructure

EMOB_Core_01. Annual energy demand by charging infrastructure

This KPI measures the total energy consumption of EVs in the PED. This is an important parameter since it will presumably have an impact into the smart grid operation. The scope of this KPI is the charging infrastructure that is integrated into the smart grid and subject to the overall energy management system of the PED.

The baseline is the average density and usage of the e-charging infrastructure in new areas in Amsterdam and Bilbao developed at the time of monitoring. The baseline areas are compatible to the PED in # dwellings, # inhabitants and level of income. The initial target for the number of charging points can be taken from the proposal. The target for the annually energy delivered is based on 1) average utilization rate of e-charging infrastructure in Amsterdam and Bilbao, comparable to the demos and 2) considerations on the optimal integration of EV-charging demand and V2G into the PED smart grid (to be discussed). This KPI only accounts for charging. The monitoring of V2G is captured in KPI MOB_Core_03

EMOB_Core_02. Relative modal shift from fossil-fuel vehicles to electric mobility in the PED area.

In Bilbao, the area considered is the whole Zorrotzaurre Island, which is the district in which the three PED areas are located. In Amsterdam, the demo area comprises the two new areas Republica and Poppies. The underlying data include:

- ✔ Annual number of passenger kilometers and number of trips in EV in relation to overall transportation demand in the area.
- ✔ Annual number of passengers using the new vehicles and/or infrastructure in relation to the total number of passengers using all modes of transportation in the area
- ✔ Electric vehicles deployed in the PED area. The number of electric vehicles (EV) registered in the area, in relation to the total number of motorized vehicles.

The baseline is the share of e-mobility in the cities of Amsterdam and Bilbao at the time of monitoring for new areas comparable to the demo areas. In both cities, an increase in e-mobility is planned over the coming years, which needs to be accounted for in the baseline. This way the impact of the PED interventions additional to business-as-usual can be established.

EMOB_Core_03. Relative share/contribution of Vehicle to Grid (V2G) to the total energy system performance of the PED

This indicator measures the total amount of energy (kWh) that is charged from Vehicle to Grid (V2G). This technological solution is currently widely explored to benefit both the EV charging demands as well as the flexibility of local energy systems. This indicator assesses its contribution to the balancing of the PED system.

The baseline is zero. V2G is in the experimental phase and only demos have been implemented in Amsterdam and in Bilbao. The target will be set on the basis of the current best-practices in the V2G pilots in Amsterdam and in Bilbao, while considering the potential for further innovation in V2G systems (to be further quantified).

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EMOB_Core_04 Relative share of EV demand covered by local RES

This indicator assesses to what extent the EVs' energy demand is covered by renewable energy produced in the PED (ENE_Core_03). The full integration of EV demand in an area is the long-term objective of positive-energy districts.

The baseline is the current RES share of the national grid at the time of monitoring. The target is 100% as the overall target of the PED is energy positivity and 100% supply by local RES. However, 100% may not be possible to achieve. Note, the estimation of the surplus energy of the demos does not include charging demand. For each demo, a feasible target will be defined on the basis of an assessment of the expected demand and potential for balancing supply and demand in the PED energy system. The RES production and EV demand will be monitored on an hourly basis, and reported as an annual average.

4.5 Citizen engagement and social impacts

Social interventions

Social interventions and innovations are based on three pillars: awareness, intentions and ability. Awareness is about perceptions: feeling the need to act. The intention is about strategies and the way to act. The following interventions and actions are planned, which hopefully will lead towards these objectives:

- Participation and stakeholder involvement communication, events and meetings, developing a sense of community; that is, feeling that you belong to the community of the PED or energy community and creating awareness on sustainability
- Other Interventions on awareness, f.e. in residence artist and citizen science projects
- Giving stakeholders capacities and resources to be able to change their behaviour as a result of 1) being informed about new technologies implemented in the smart homes, and 2) learning of new skills (in relation to the new technologies implemented in the smart homes), and 3) ATELIER meetings – structured meetings and discussions with diverse group of stakeholders to raise and solve issues (f.e. on data, ownership, governance, regulation, technology) of the PED.

Principles and approach to social KPIs

Scope of social performance

Social performance is crucial to estimate the extent to which the project and its designed collaborative action model facilitates the involvement of citizens and social actors in the planning, decision-making and implementation activities through social citizen-driven innovation mechanisms. In this project we want to even go a bit further and work with specific dynamic KPI's in order to monitor participation.

Innovation: dynamic KPIs

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 864374.

Participation is not a goal itself but a means to engage stakeholders and give them an action perspective living and contributing to a PED. It is important to monitor, as an important means to reach the overall goals of the project. But it can be an elusive factor to measure. Nonetheless, it is important to set and communicate clear goals, demonstrate outcomes, and assess our activities related to participation, engagement, and co-creation in Atelier. Therefore, we introduce dynamic (in addition to more static) KPIs, those for project activities related to social engagement and related participatory activities. Focus is on measuring three main factors related to participation in ATELIER. These include:

1. Technical community indicators (quantitative research),
2. Vision and impact (mix of qualitative and quantitative research),
3. The pulse, feeling, and reaction (qualitative research).

Before considering numbers or targets, we have to first go through the process of making connections between how you approach your goals, your stakeholders, and the goals of your stakeholders.

From output-oriented to outcome/impact indicators

1. **Output-oriented KPIs:** These KPIs are concrete indicators for monitoring the progress and effectiveness of implementation of project activities (e.g. nr of stakeholder meetings, or nr of citizens reached)

2. **Impact (outcome) oriented KPIs**: These indicators should assess the benefits of interventions as well as the higher-level goals to which ATELIER will contribute. Examples are: share of citizens actively engaging in energy communities; change in behaviour.

In the social domain, it is difficult to use impact oriented KPIs because of the complexity of drivers and factors that influence social changes. Therefore, very often, qualitative process oriented KPIs are used, complemented with a qualitative assessment to assess the related impact. In ATELIER, we will apply innovative social impact assessment methods, to strengthen the validity of the monitoring and evaluation of social impact.

We built upon the transition theory. Networks and behaviour of people in the networks change because of beliefs, actions and changing actors and collaboration. This can be monitored using a multiplayer network perspective: Users of the PED can embrace innovation and technology and are able to efficiently use natural resources.

Two M&E areas in social performance

KPIs are part of the monitoring and evaluation (M&E) framework. We distinguish these two different impact/result areas, for which social KPIs are needed:

1. The impact of ATELIER in the social domain, such as employment and wellbeing in the PED district.

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2. The results of the project activities on stakeholder and citizen engagement, such as the increased engagement of the PED residents in the PED activities.

There is a strong link between these two areas. The monitoring approach will be different, as a different set of project activities contribute to 1 and 2 respectively and different monitoring approaches will be applied. In the project evaluation the two areas will be assessed in an integrated way.

Indicators proposed for citizen engagement and social impacts

In this evaluation domain we distinguish four KPIs that capture ATELIER's social interventions and targets. Benchmarking of these KPIs with other SCC projects, especially those addressing PEDs, is vital to allow the evaluation of the social impact and citizen engagement.

SOC_Core_01: Improvement of quality of life for the PED inhabitants

Quality of Life (QoL) is an important measurement for cities' liveability and habitability. QoL refers to an individual's perception of his or her position in life in the context of the culture and value systems in relation to goals, expectations, standards and concerns". It has been clearly shown that people's relation to their living environments is a key issue in their quality of life. Well-designed housing has been identified as an important factor in promoting quality of life. Good quality housing is also instrumental in fulfilling the health and social care agendas. In ATELIER, the underlying hypothesis is that living in a PED increases quality of life.

In this project, we define the indicators of quality of life by inhabitants themselves, in co-creation with researchers and project partners and stakeholders. The focus will be on those aspects that are specific for PEDs, such as the local community, sustainability, energy citizenships, and citizen engagement. The level of perceived comfort is input to this KPI. The process is based upon the Neighborhood Sustainability Indicators Guidebook [14]

We measure if and how the quality of life of the PED inhabitants has improved by the project, and try also to find out for whom, and if there are differences between gender, age, participation in the project etc. This can provide insights to specific target groups for the participation actions and interventions.

The quality of life will be measured 3 times in the project: firstly, when the inhabitants move into the dwelling (baseline); secondly, just before the main interventions are implemented, and finally, towards the end of the project (target).

The baseline is the average of perceived quality of life of a representative part of people living in the demos at the start. The target is significant improvement of QoL, attributed to the PED characteristics and interventions

The first measurement is done by interviews / queries in the neighborhood of all demos. The query is based on the method of measuring neighbourhood quality of life using placed-based sustainability indicators.

SOC_Core_02: Progress towards energy citizenship

Energy citizenship is described as civic engagement, active participation, and interaction with institutional or corporate actors in the context of energy transitions for climate-neutral cities.

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This includes processes of planning and co-management of the city related energy system. This relates to the following questions: What kind of narrative and communication styles drive social change? What kind of environment allows for ambitious goal setting, strong commitments, and active involvement in the production of energy and energy-efficient consumption? How does technology play a role in fostering or not energy citizenship in processes of smart planning, smart co-management of energy systems (supply and demand side)?

PEDs aim to foster energy citizenships through a comprehensive set of interventions. In the Amsterdam demo's energy communities will be built. Citizens are invited, a.o. to play a role in the governance of the PED, participate in local energy and flexibility, select sustainable mobility modes. Also, they may have a say in the design of the buildings they live in.

The methodology in assessing this KPI will be further developed, taking into account the following aspects, amongst others: social acceptance of PED solution, personal attitudes and motivation, perceived incentives /barriers, available (technical and market) options, level of trust, sense of community, technology perception, and ICT literacy.

Input to this KPs is provided by underlying data on the engagement of citizens in the specific activities (memberships energy communities, trading, stakeholder meetings, DSM, e-mobility, PED governance, etc.) in quantitative terms (evaluation domains energy, e-mobility, economic impact and business development). In addition, surveys and in-depth interviews will provide additional information on the motivation, drivers and barriers, and progress that individuals and households make on their road toward becoming energy citizens. Also, this KPI is essential input to the evaluation of the expected potential in upscaling and replication, when it will become necessary to engage a wider range of citizens groups, not only the motivated frontrunners.

SOC_Core_03: Impact on habits and lifestyle towards sustainability

The PED will create an environment for its inhabitants, which will provide them with options to act, incentives and information on how to reduce their energy, ecological and sustainability footprint of their lifestyle. ATELIER aims that this will have positive impacts beyond the direct impacts of the PED on energy and GHG emissions. This KPI will monitor the changes in habits and lifestyle of the inhabitants that can be attributed to the PED interventions and the PED building environment.

The first step in monitoring is the mapping and analysis of the PED population, their current motivations and attitudes, and current lifestyle and habits. The characteristics of the PED inhabitants may differ from the general public as the new buildings in the PED in Amsterdam are marketed as sustainable dwellings and may attract inhabitants that already have a sustainable lifestyle to start with.

Subsequently, the causality between interventions and changing in behaviour and lifestyle will be studied and understood. Issues like crowding out (or moral licensing) and spill-over will be assessed. Crowding out occurs when individuals feel that living in a very sustainable building will allow them to have more unsustainable habits in other areas; spill-over is the reverse: a sustainable building motivates in other areas. The PED specific target still needs to be defined

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but will reflect a level in improvement of habits and lifestyle that will lead to a significant impact on the lifecycle performance of the PED.

The methods for monitoring will be further developed but will include surveys and interviews at various stages of the projects, and other techniques drawn from the psychological and behavioural sciences.

SOC_Core_04: Feeling the pulse - monitoring citizen engagement

This KPI addresses the progress and success of the engagement approaches and activities ("Feeling the pulse"). This KPI is structurally following which people are involved in the PED demo sites and how they feel about it (PULSE). It will keep track of the acceptance of participation projects and interventions. This KPI is based on 2 kinds of information:

- Quantitative mapping of the people involved in the PED demos (gender, age, …)
- Qualitative measurement of the pulse, feeling, satisfaction, and response to the participation.

The following underlying data will be gathered through a.o. surveys and interviews:

- What feeling do stakeholders have around the participation process? Levels of trust and satisfaction?
- What stops people from engaging? Are people disconnecting from the participation activities, and why?
- Representativeness of the active citizens

We differentiate between 1) the inhabitants of the PEDs and 2) inhabitants and stakeholders in the wider district, in particular those that could be included in the PED at a later stage (upscaling). The engagement will be broader for the PED inhabitants, while the success of engaging the neighboring citizens is crucial for future upscaling.

4.6 KPIs on upscaling, replication and governance

We view upscaling and replication as a key objective of ATELIER because the performance of the PED demonstrations is less relevant if they cannot be upscaled (grow in size) or replicated in the same or in other cities. Governance is a critical aspect of the enabling environment for upscaling and replication, and we, therefore, include it in this evaluation domain. We define governance as following: the set of policy, regulatory, administrative and communication interventions available to the public sector to achieve an overarching strategic target. We focus on governance at city level by the city administration, but include essential governance at EU, national and local level, as these levels strongly either support city level governance or restrict it. Examples are energy market regulation, which is set at EU and national level, and the ownership and governance models for specific PEDs, which is to a large extent not under the control of the city administration.

As such, input to the monitoring of these KPIs is provided by several ATELIER activities:

- Definition of LHC visions for 2025, which provides strategic framework and targets, and addresses the upscaling and replicability at city level

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- The Innovation Ateliers as core element of ATELIER for the discussion and co-definition of solutions withing the quadruple helix (public authorities, industry, academia and citizenship)
- PED demonstration at LHCs that addresses the governance model at PED level, and assess the upscaling approaches of the entire cities
- Analysis of the replicability process in the Fellow Cities

Indicators proposed for upscaling, replication and governance

UPS_Core_01 Suitability of the locations in Fellow Cities for PEDs

As a first step towards replication, the Fellow Cities have identified initial locations for PED development. The suitability of these is a good indicator for the readiness of the cities for PEDs. To this purpose, the replicability to fellow cities will develop a multi-criteria evaluation framework to assess the suitability and the potential, and to guide the cities in their planning. This could imply a change in location in some Fellow Cities, if necessary. The target is that at the end of ATELIER all Fellow Cities will have identified and prepared one or more locations, where implementation could start on the basis of the finalised Replication Plan (see next KPI). In addition, the same KPIs will be applied in Lighthouse cities to assess the progress in suitability for replication of the demonstration PED in the city.

A visualised scoreboard with qualitative steps will be developed, complemented with critical milestones in achieving full readiness for implementation of a PED in the designated location. This will be assessed using a reflective approach where key stakeholders in the cities evaluate progress and through benchmarking towards progress in other cities.

UPS_Core_02 Progress of Fellow Cities in the replicability of PED implementation

The Fellow Cities will be supported in preparing the investment planning and implementation of one or more PEDs. This will be captured in the replication plan for each city. In the PED execution plans, cities will be supporting in defining a suitable business model for the PED defined and, in the replication and upscaling plans the idea is to define an investment planning. The main inputs to this indicator are the progress of the replicability plan, progress in the financial closure of the investment, the progress in governance, the level of commitment of all stakeholders, political commitment to be verified by city level decisions, by administration and council, the results of capacity building, and the progress in innovation as supported by the city's innovation Ateliers.

A visualised scoreboard with qualitative steps will be developed, complemented with critical milestones and indicators in the progress towards replication.

UPS_Core_3 Progress at the PED demonstrations towards upscaling

Upscaling of a PED is the enlargement and growth of an initial PED in terms of geographical size, number of consumers, and volume of production and demand. This can be achieved by adding buildings and other energy consumers, as well as production facilities to the existing smart grid and energy management system.

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The governance structure of the PED should facilitate 1) the optimal operation of the PED in light of its social, economic, energy and environmental objectives, and 2) the upscaling of the PED by making it easy for homeowners, home-owner associations, building owners, grid operators and other parties to "join the party".

To this purpose, for each PED demo, an upscaling plan will be developed, preferably leading the upscaling during ATELIER already. The target is that upscaling will be achieved at the latest immediately after finalisation of ATELIER. The plan should address upscaling of the governance system, the technical enlargement of the PED energy systems, business development for upscaling, and citizen engagement.

A visualised scoreboard with qualitative steps will be developed, complemented with critical milestones in the progress towards upscaling

UPS_Core_04 Progress in governance (enabling policy, legal and planning framework) in Lighthouse and Fellow Cities

Most PEDs, at least in Europe, will involve urban renewal and retrofit. Given the complex context, it will therefore not be possible to realise a PED overnight. Managing the urban transformation process will require a well-conceived governance process.

Governance encompasses both reducing the barriers and enhancing the drivers for upscaling and replication. These are covered in the other evaluation domains: technical barriers and drivers under Energy; economic aspects under Economic Impact and Business Development, and the social component under Social Impact and Citizen Engagement. This KPI aims to capture the comprehensive development and operation of a governance model.

A visualised scoreboard with qualitative steps will be developed to capture the progress in the enabling governance domains, complemented with critical milestones in the progress towards replication. Radar maps are used as illustration.

4.7 Indicators proposed for knowledge generation and sharing

ATELIER aims to generate new knowledge in a wide range of areas relevant for the design, implementation and replication of PEDs. This is performed through monitoring and evaluation of the PED demonstrations, specific research activities, engagement with stakeholders, and collaboration with other projects. Knowledge generation and sharing constitutes a complex process which is facilitated by ATELIER's Communication and Dissemination activities in collaboration with the entire project team as laid down in the corresponding project report. The "knowledge process" encompasses the measurement and experience of a new solution or innovation, evaluating and interpreting the experience as an enabler for broader transformation, and combining it into a social and organisational learning process. Ultimately, this allows a deep and real process of knowledge generation and sharing. Related to the generation and sharing of knowledge, four KPIs are established to measure the performance along this dimension.

KNO_Core_1 Number of scientific publications (peer reviewed)

The most scientifically thorough and in-depth channel for reporting the results of the research on PEDs in ATELIER is through peer reviewed scientific publication. Although the number of

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publications is not a very accurate indicator for the scientific value of the research, it is simple, straightforward and links to the direct output of ATELIER partners. Accordingly, the academic and research partners of ATELIER will play a leading role in contributing to this KPI.

KNO_Core_2. Number of public papers and conference contributions (non-peer reviewed)

Besides dissemination in the academic community, ATELIER will inform the broad public audience by publishing continuously on the ambition of communicating the project objectives and ambitions and disseminating project results. ATELIER partners will use a wide range of instruments to approach project stakeholders and the general public. Some examples are news articles, press releases, opinion papers, newsletters, etc. In addition, we contribute to seminars and conferences through presentations or posters. These publications are a rapid and flexible way in sharing knowledge directly to a broad audience and, thus, complement the project deliverables and scientific publications.

KNO_Core_3 Number of info-packages on PED smart solutions

ATELIER will produce a series of info-packages on specific PED smart solutions. These are concise, provide a brief background, present case studies and best practices. They differentiate from general public papers as they address selected smart PED solutions specifically and include, as such, different sorts of materials that will be tailored to different audiences. For example, ATELIER partners will produce: best practice booklets for politicians, industry, NGOs, etc.; webinars for City Representatives, industry, academia, etc.; student lectures and MOOCs for students and teachers, etc. The info-packages provide an easy to use set of tools that facilitate the dissemination of specific project results.

KNO_Core_4. Seminars, workshops and events organized and participated

ATELIER partners will participate in a wide range of events that include those organised by the consortium members and other international or European events (conferences, symposiums, expositions, etc.). In sum, they contribute with knowledge sharing and generation in a very trans-disciplinary approach since ATELIER partners will have the opportunity to meet with multiple agents from academia, public administrations, consultancies, engineering firms, etc. covering and discussing technical chapters, as well as other economic issues, legal perspectives, etc.

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5. Next steps and working tools

This public report constitutes the guiding document for Monitoring and Evaluation of ATELIER. It is a methodological document that defines the basis for monitoring and evaluation. It is delivered in October 2020 (M12) and will be regularly followed up and advanced with the consortium members. The Core Group is responsible for keeping this live document updated, and to provide the tools and instruments that ensure its implementation.

The ATELIER consortium has a shared working space (Figure 21):

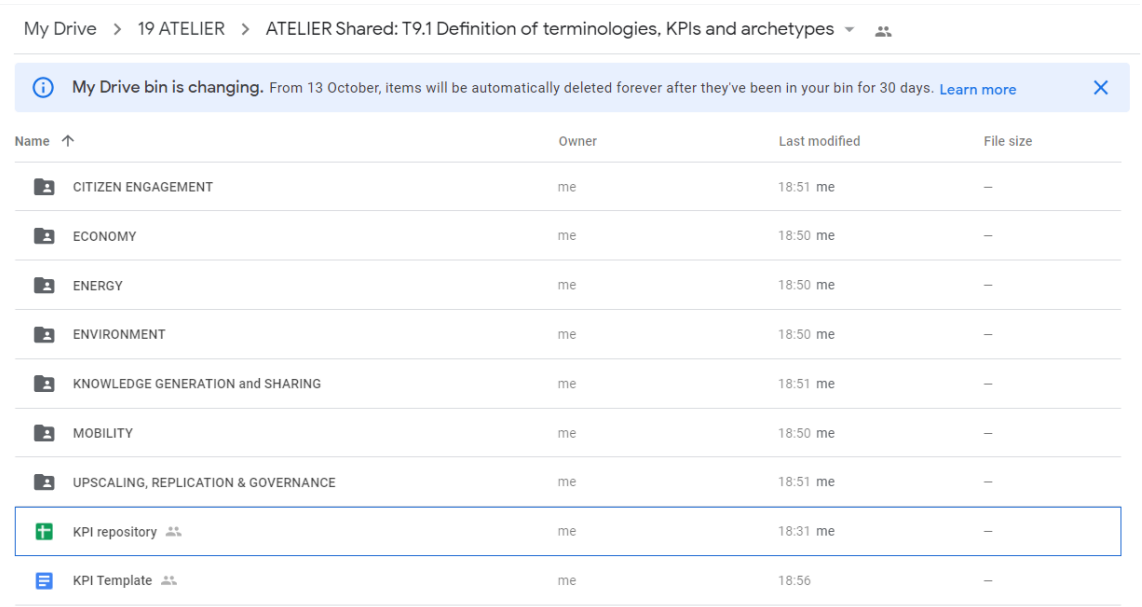

Figure 21. ATELIER Monitoring and Evaluation framework shared space

The shared tools include:

- ✔ Spreadsheet with KPI definition (see Annex 1): includes all the sections in the template and some additional fields as the linked Actions in Bilbao and Amsterdam, KPI Value, Time Horizon, etc.
- ✔ Template for KPI detailed definition (see Annex 2)
- ✔ SCIS Monitoring Guides proposal of PKIs (Annex 3)
- ✔ A folder for each evaluation domain where we will gather one live template for each KPI

During next period (M12-M18) the core group will organize:

- ✔ A seminar with all project partners to present the overall framework and collaboration instruments (KPI templates, common repository systems, etc.)
- ✔ Parallel meetings with local ecosystem partners that might update and contribute with the definition of KPIs, calculation methods, specific baseline definition, etc.

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The core group in close collaboration with KPI owners and Data providers will ensure the consistency of the KPI estimation methods with the real availability of data at the PEDs, ensuring the transparency of the methods and the comparability of the results.

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REFERENCES

[1] EU Smart Cities Information System, Monitoring KPI Guide, 2018, D23.1. From: https://smart-cities-marketplace.ec.europa.eu/insights/publications/self-reporting-tool-key-performance-indicators-guide

[2] Efficiency Valuation Organization. International Performance Measurement and Verification Protocol (IPMVP), 2016. From: https://evo-world.org/en/products-services-mainmenu-en/protocols/ipmvp

[3] CityXChange Project, Grant Agreement No.: 824260. Deliverable 7.1 Approach and Methodology for Monitoring and Evaluation (2020). From: https://cityxchange.eu/knowledge-base/

[4] CivitasWiki Project; Grant Agreement No.: 296081. Deliverable 4.10: Applied framework for evaluation in CIVITAS PLUS II; CIVITAS Secretariat, EC: Brussels, Belgium, 2013. From: https://civitas.eu/sites/default/files/civitas_wiki_d4_10_evaluation_framework.pdf

[5] CityXChange Project, Grant Agreement No.: 824260. Deliverable 7.2: Reporting to the SCIS system (2019). From: https://cityxchange.eu/knowledge-base/

[6] EU Smart Cities Information System, Social Monitoring Guide, 2018, D23.2A. From: https://smart-cities-marketplace.ec.europa.eu/insights/publications/social-monitoring-guide--

[7] EU Smart Cities Information System, Self Reporting Tool (SRT) Guide, 2020. From: https://smart-cities-marketplace.ec.europa.eu/insights/publications/self-reporting-tool-srt-guide

[8] EU Smart Cities Information System, Technical Monitoring Guide, 2018, D23.2D. From: https://smart-cities-marketplace.ec.europa.eu/insights/publications/technical-monitoring-guide

[9] EU Smart Cities Information System, Policy and Finance Monitoring Guide, 2018, D23.2B. From: https://smart-cities-marketplace.ec.europa.eu/insights/publications/policy-and-finance-monitoring-guide

[10] EU Smart Cities Information System, Economic Monitoring Guide, 2018, D23.2C, 2018. From: https://smart-cities-marketplace.ec.europa.eu/insights/publications/economic-monitoring-guide

[11] K. Angelakoglou, Konstantinos Kourtzanidis, P. Giourka, V. Apostolopoulos, N. Nikolopoulos, J. Kantorovitch (2020). From a Comprehensive Pool to a Project-Specific List of Key Performance Indicators for Monitoring the Positive Energy Transition of Smart Cities—An Experience-Based Approach. Smart Cities 2020, 3, 705–735; doi:10.3390/smartcities3030036.

[12] IRENA (2018), Renewable Energy Statistics 2018, The International Renewable Energy Agency, Abu Dhabi.

[13] Sala, S., Cerutti, A. and Pant, R., Development of a weighting approach for the Environmental Footprint, EUR 28562 EN, Publications Office of the European Union, Luxembourg, 2017, ISBN 978-92-79-68041-0 (print),978-92-79-68042-7 (pdf), doi:10.2760/945290 (online),10.2760/446145 (print), JRC106545. Available at: https://ec.europa.eu/jrc/en/publication/development-weighting-approach-environmental-footprint

[14] Neighborhood Sustainability Indicators Guidebook: How To Create Neighborhood Sustainability Indicators in Your Neighborhood February, 1999 Produced for the Urban Ecology Coalition (Minneapolis): https://www.crcworks.org/guide.pdf

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Annex 1: KPI REPOSITORY

OCTOBER 2020

Linked to D9.1 (FIRST DRAFT): Repository of definitions of terms, key characteristics archetypes, and a set of KPIs

AmsTErdam BiLbao cItizen drivEn smaRt cities

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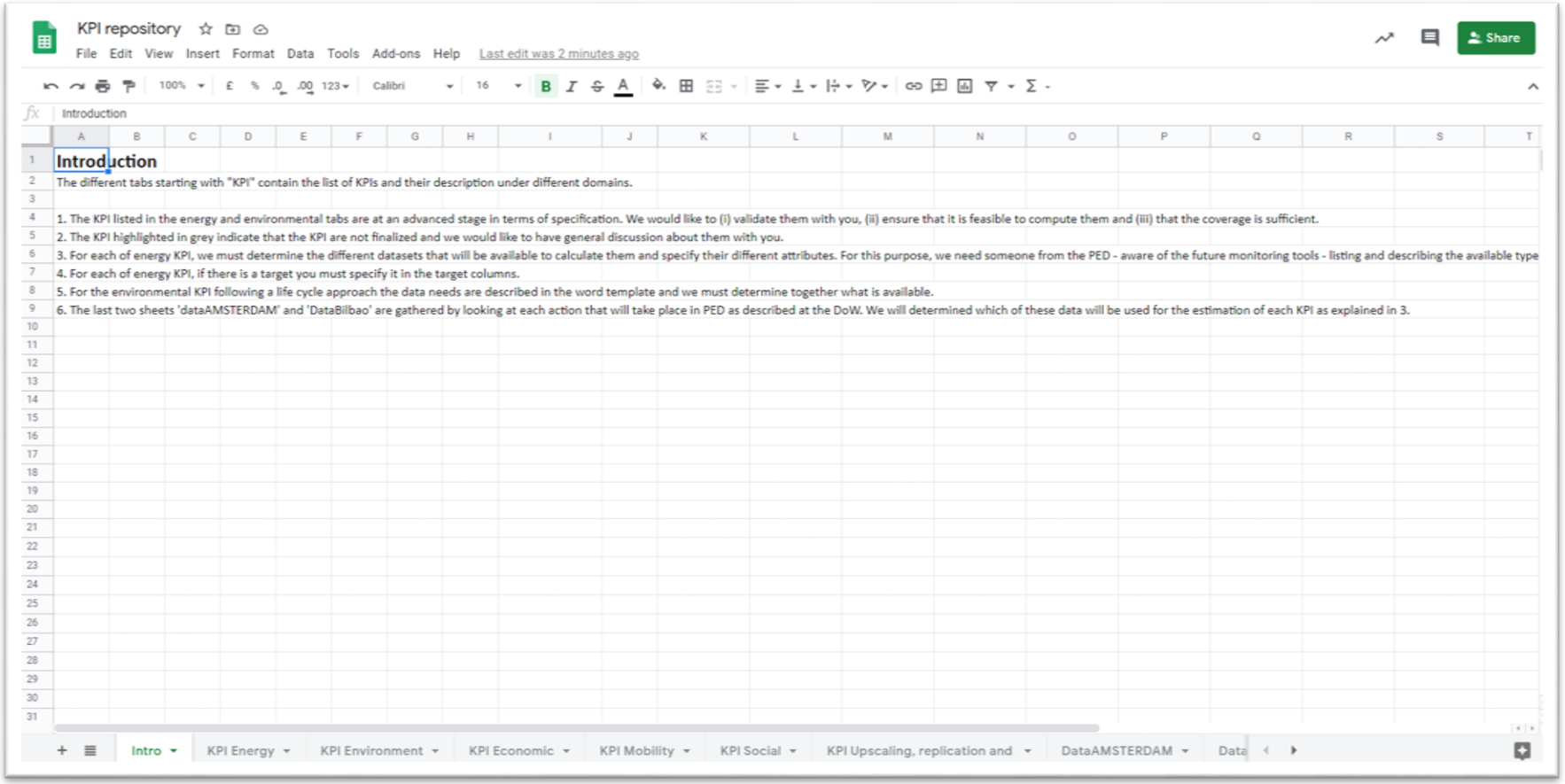

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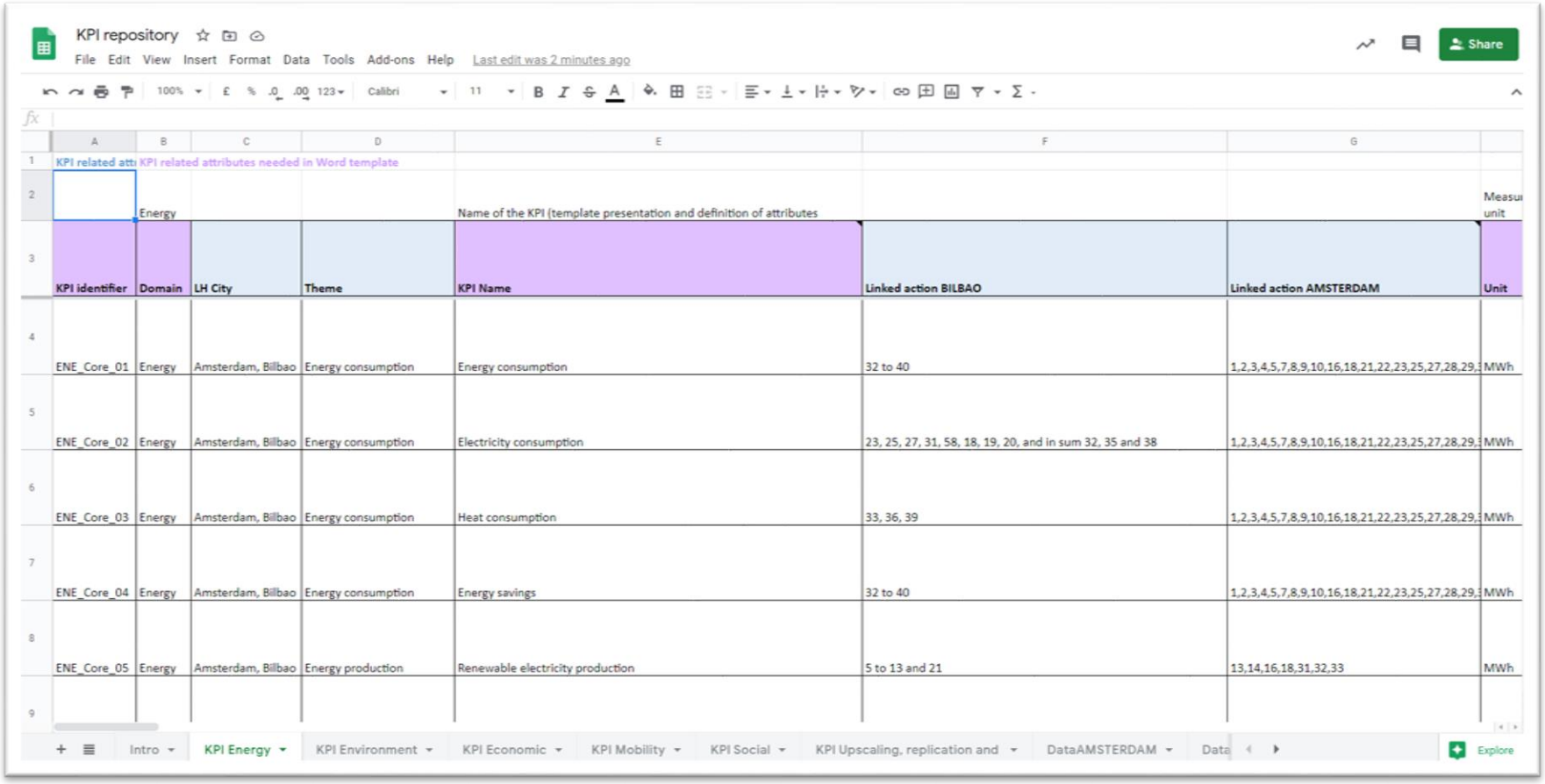

KPI repository

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1	KPI related atti	KPI related attributes needed in Word template						
2		Energy			Name of the KPI (template presentation and definition of attributes			Measu unit
3	**KPI identifier**	**Domain**	**LH City**	**Theme**	**KPI Name**	**Linked action BILBAO**	**Linked action AMSTERDAM**	**Unit**
4	ENE_Core_01	Energy	Amsterdam, Bilbao	Energy consumption	Energy consumption	32 to 40	1,2,3,4,5,7,8,9,10,16,18,21,22,23,25,27,28,29,	MWh
5	ENE_Core_02	Energy	Amsterdam, Bilbao	Energy consumption	Electricity consumption	23, 25, 27, 31, 58, 18, 19, 20, and in sum 32, 35 and 38	1,2,3,4,5,7,8,9,10,16,18,21,22,23,25,27,28,29,	MWh
6	ENE_Core_03	Energy	Amsterdam, Bilbao	Energy consumption	Heat consumption	33, 36, 39	1,2,3,4,5,7,8,9,10,16,18,21,22,23,25,27,28,29,	MWh
7	ENE_Core_04	Energy	Amsterdam, Bilbao	Energy consumption	Energy savings	32 to 40	1,2,3,4,5,7,8,9,10,16,18,21,22,23,25,27,28,29,	MWh
8	ENE_Core_05	Energy	Amsterdam, Bilbao	Energy production	Renewable electricity production	5 to 13 and 21	13,14,16,18,31,32,33	MWh
9								

Intro | KPI Energy | KPI Environment | KPI Economic | KPI Mobility | KPI Social | KPI Upscaling, replication and | DataAMSTERDAM | Data | Explore

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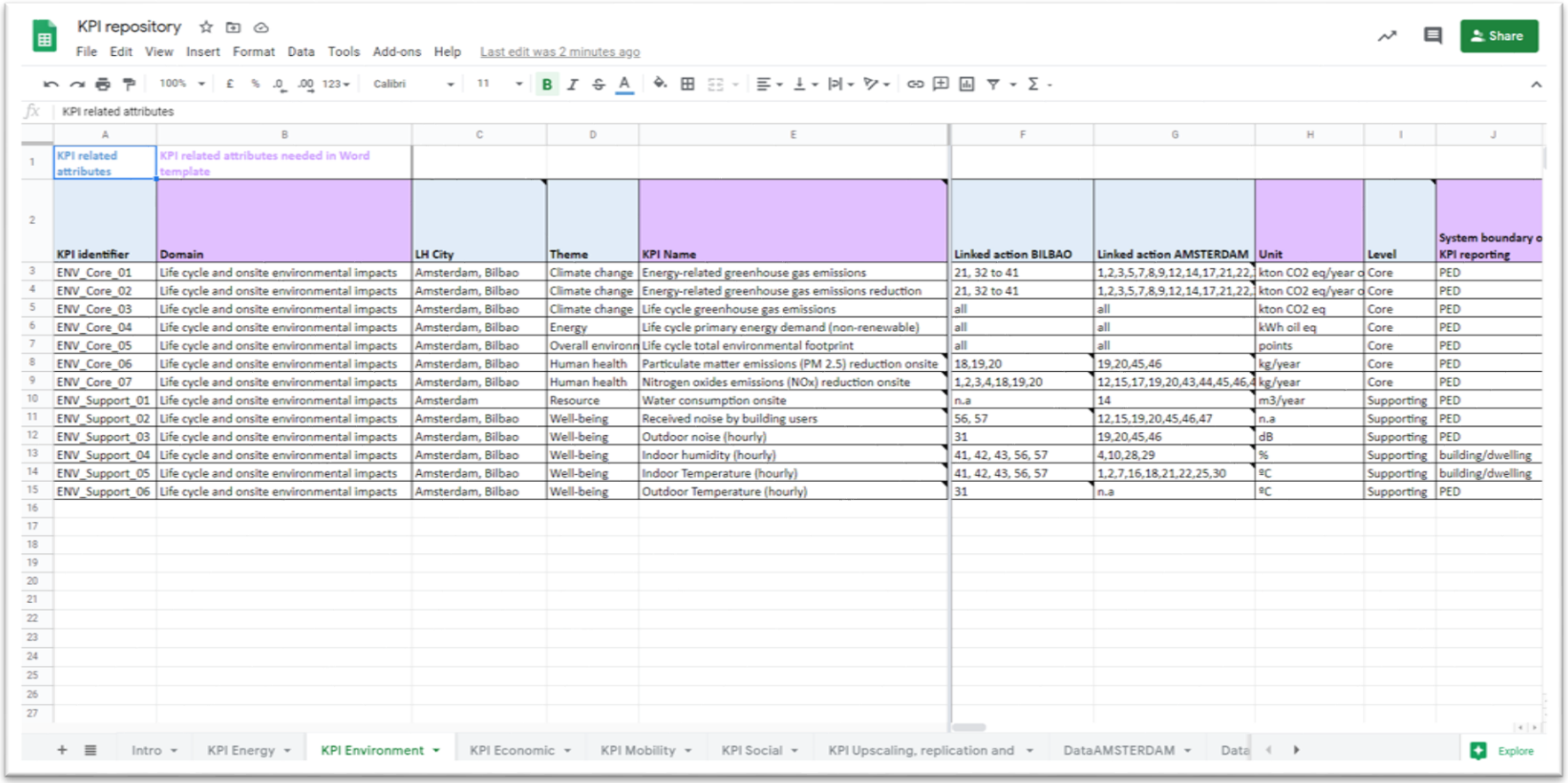

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KPI related attributes

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2	KPI identifier	Domain	LH City	Theme	KPI Name	Linked action BILBAO	Linked action AMSTERDAM	Unit	Level	System boundary o KPI reporting
3	ENV_Core_01	Life cycle and onsite environmental impacts	Amsterdam, Bilbao	Climate change	Energy-related greenhouse gas emissions	21, 32 to 41	1,2,3,5,7,8,9,12,14,17,21,22,	kton CO2 eq/year o	Core	PED
4	ENV_Core_02	Life cycle and onsite environmental impacts	Amsterdam, Bilbao	Climate change	Energy-related greenhouse gas emissions reduction	21, 32 to 41	1,2,3,5,7,8,9,12,14,17,21,22,	kton CO2 eq/year o	Core	PED
5	ENV_Core_03	Life cycle and onsite environmental impacts	Amsterdam, Bilbao	Climate change	Life cycle greenhouse gas emissions	all	all	kton CO2 eq	Core	PED
6	ENV_Core_04	Life cycle and onsite environmental impacts	Amsterdam, Bilbao	Energy	Life cycle primary energy demand (non-renewable)	all	all	kWh oil eq	Core	PED
7	ENV_Core_05	Life cycle and onsite environmental impacts	Amsterdam, Bilbao	Overall environn	Life cycle total environmental footprint	all	all	points	Core	PED
8	ENV_Core_06	Life cycle and onsite environmental impacts	Amsterdam, Bilbao	Human health	Particulate matter emissions (PM 2.5) reduction onsite	18,19,20	19,20,45,46	kg/year	Core	PED
9	ENV_Core_07	Life cycle and onsite environmental impacts	Amsterdam, Bilbao	Human health	Nitrogen oxides emissions (NOx) reduction onsite	1,2,3,4,18,19,20	12,15,17,19,20,43,44,45,46,4	kg/year	Core	PED
10	ENV_Support_01	Life cycle and onsite environmental impacts	Amsterdam	Resource	Water consumption onsite	n.a	14	m3/year	Supporting	PED
11	ENV_Support_02	Life cycle and onsite environmental impacts	Amsterdam, Bilbao	Well-being	Received noise by building users	56, 57	12,15,19,20,45,46,47	n.a	Supporting	PED
12	ENV_Support_03	Life cycle and onsite environmental impacts	Amsterdam, Bilbao	Well-being	Outdoor noise (hourly)	31	19,20,45,46	dB	Supporting	PED
13	ENV_Support_04	Life cycle and onsite environmental impacts	Amsterdam, Bilbao	Well-being	Indoor humidity (hourly)	41, 42, 43, 56, 57	4,10,28,29	%	Supporting	building/dwelling
14	ENV_Support_05	Life cycle and onsite environmental impacts	Amsterdam, Bilbao	Well-being	Indoor Temperature (hourly)	41, 42, 43, 56, 57	1,2,7,16,18,21,22,25,30	ºC	Supporting	building/dwelling
15	ENV_Support_06	Life cycle and onsite environmental impacts	Amsterdam, Bilbao	Well-being	Outdoor Temperature (hourly)	31	n.a	ºC	Supporting	PED
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Intro | KPI Energy | KPI Environment | KPI Economic | KPI Mobility | KPI Social | KPI Upscaling, replication and | DataAMSTERDAM | Data | Explore

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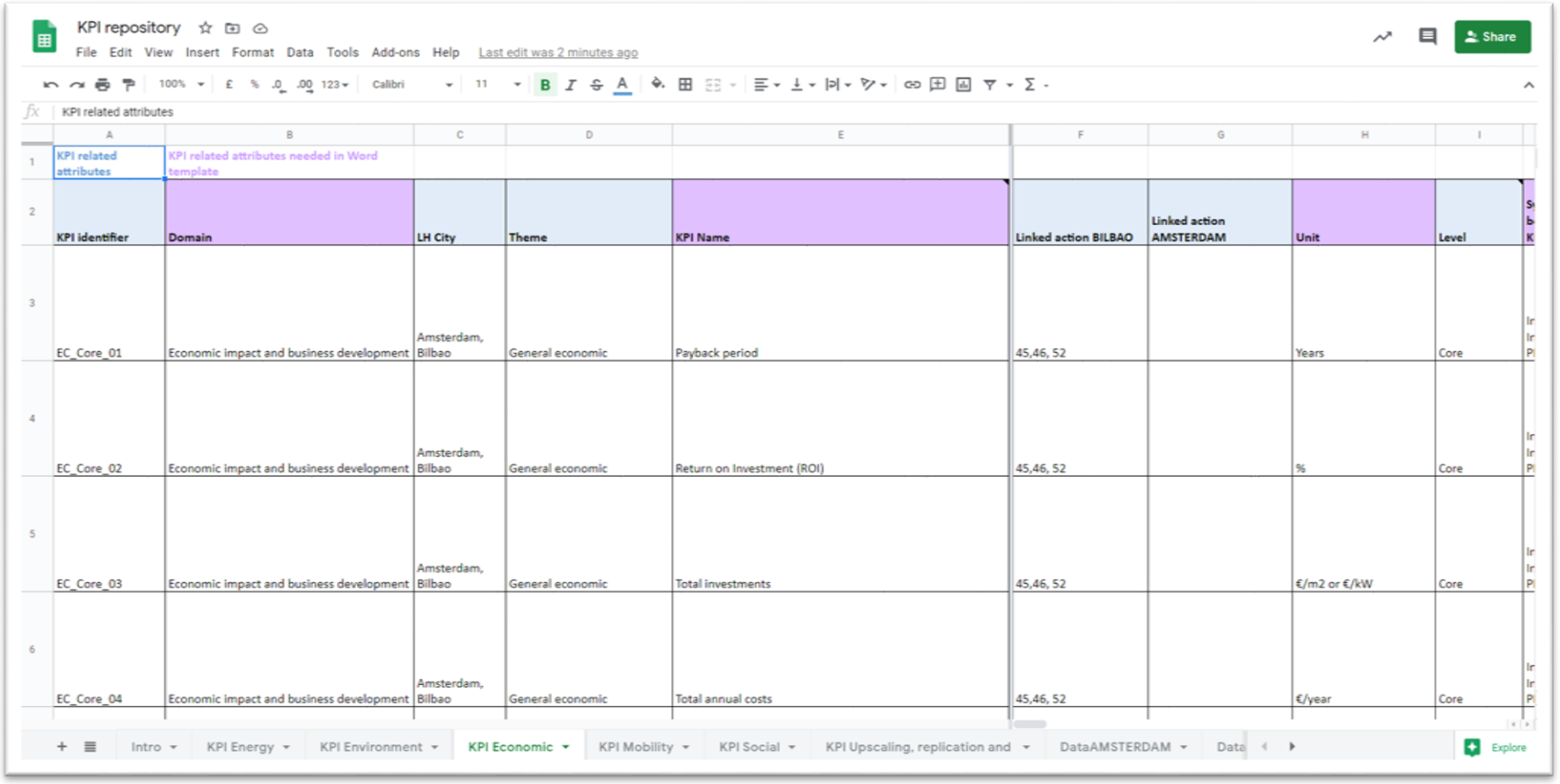

KPI repository

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KPI related attributes

	A	B	C	D	E	F	G	H	I
1	KPI related attributes	KPI related attributes needed in Word template							
2	**KPI identifier**	**Domain**	**LH City**	**Theme**	**KPI Name**	**Linked action BILBAO**	**Linked action AMSTERDAM**	**Unit**	**Level**
3	EC_Core_01	Economic impact and business development	Amsterdam, Bilbao	General economic	Payback period	45,46, 52		Years	Core
4	EC_Core_02	Economic impact and business development	Amsterdam, Bilbao	General economic	Return on Investment (ROI)	45,46, 52		%	Core
5	EC_Core_03	Economic impact and business development	Amsterdam, Bilbao	General economic	Total investments	45,46, 52		€/m2 or €/kW	Core
6	EC_Core_04	Economic impact and business development	Amsterdam, Bilbao	General economic	Total annual costs	45,46, 52		€/year	Core

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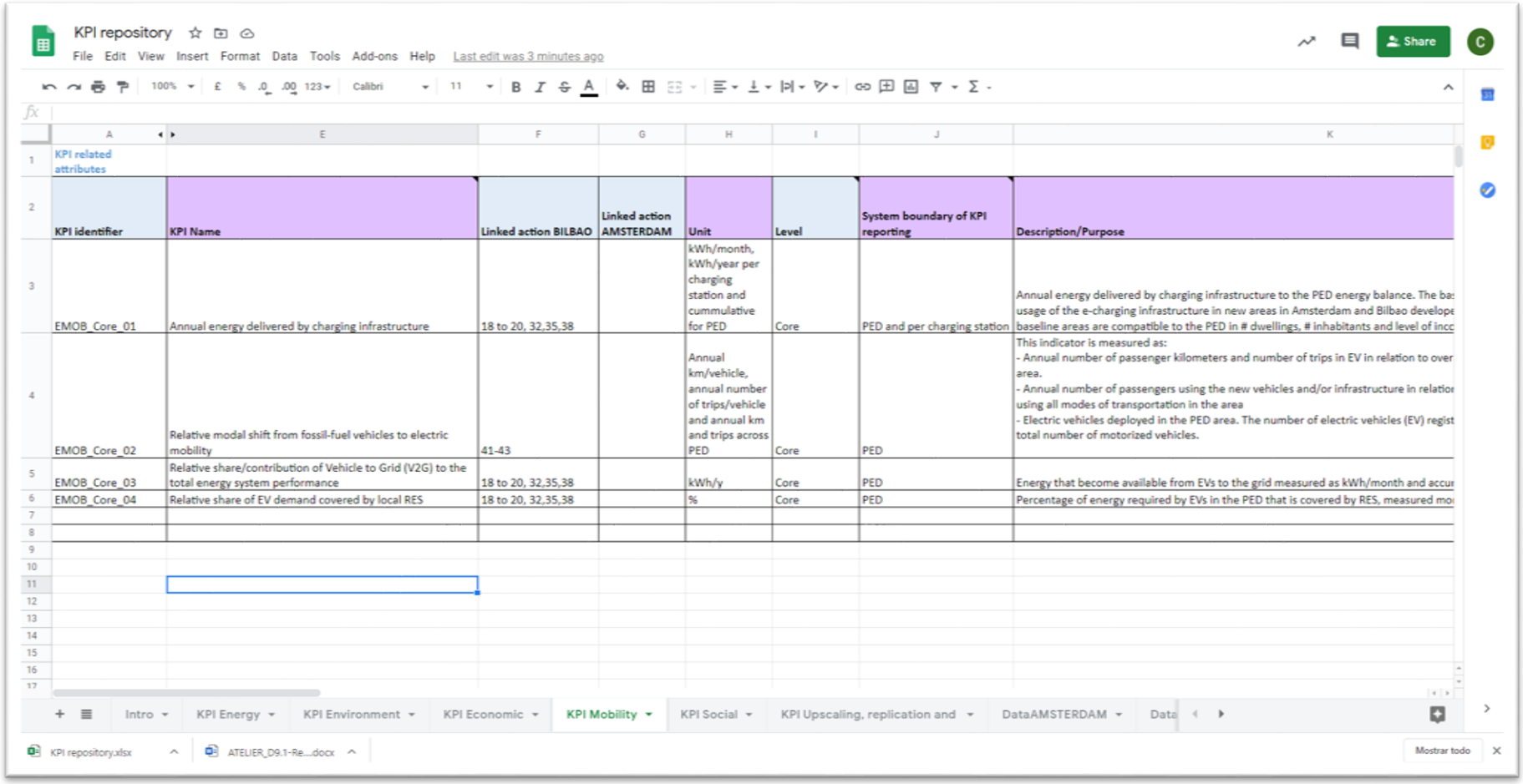

KPI repository

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	A	E	F	G	H	I	J	K
1	KPI related attributes							
2	**KPI identifier**	**KPI Name**	**Linked action BILBAO**	**Linked action AMSTERDAM**	**Unit**	**Level**	**System boundary of KPI reporting**	**Description/Purpose**
3	EMOB_Core_01	Annual energy delivered by charging infrastructure	18 to 20, 32,35,38		kWh/month, kWh/year per charging station and cummulative for PED	Core	PED and per charging station	Annual energy delivered by charging infrastructure to the PED energy balance. The ba usage of the e-charging infrastructure in new areas in Amsterdam and Bilbao develope baseline areas are compatible to the PED in # dwellings, # inhabitants and level of incc
4	EMOB_Core_02	Relative modal shift from fossil-fuel vehicles to electric mobility	41-43		Annual km/vehicle, annual number of trips/vehicle and annual km and trips across PED	Core	PED	This indicator is measured as: - Annual number of passenger kilometers and number of trips in EV in relation to over area. - Annual number of passengers using the new vehicles and/or infrastructure in relatio using all modes of transportation in the area - Electric vehicles deployed in the PED area. The number of electric vehicles (EV) regist total number of motorized vehicles.
5	EMOB_Core_03	Relative share/contribution of Vehicle to Grid (V2G) to the total energy system performance	18 to 20, 32,35,38		kWh/y	Core	PED	Energy that become available from EVs to the grid measured as kWh/month and accu
6	EMOB_Core_04	Relative share of EV demand covered by local RES	18 to 20, 32,35,38		%	Core	PED	Percentage of energy required by EVs in the PED that is covered by RES, measured mo
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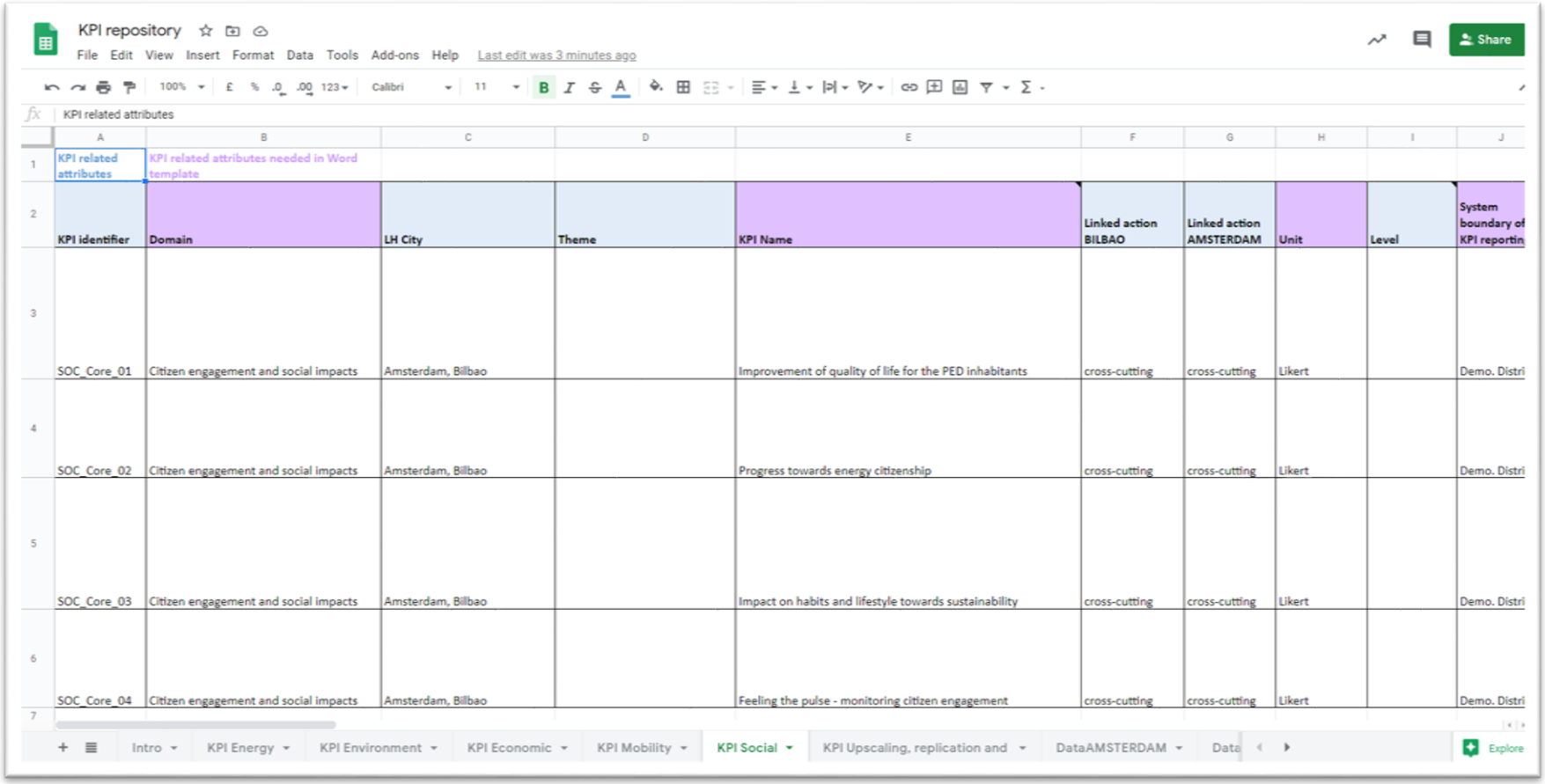

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KPI related attributes

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1	KPI related attributes	KPI related attributes needed in Word template								
2	KPI identifier	Domain	LH City	Theme	KPI Name	Linked action BILBAO	Linked action AMSTERDAM	Unit	Level	System boundary of KPI reportin
3	SOC_Core_01	Citizen engagement and social impacts	Amsterdam, Bilbao		Improvement of quality of life for the PED inhabitants	cross-cutting	cross-cutting	Likert		Demo. Distri
4	SOC_Core_02	Citizen engagement and social impacts	Amsterdam, Bilbao		Progress towards energy citizenship	cross-cutting	cross-cutting	Likert		Demo. Distri
5	SOC_Core_03	Citizen engagement and social impacts	Amsterdam, Bilbao		Impact on habits and lifestyle towards sustainability	cross-cutting	cross-cutting	Likert		Demo. Distri
6	SOC_Core_04	Citizen engagement and social impacts	Amsterdam, Bilbao		Feeling the pulse - monitoring citizen engagement	cross-cutting	cross-cutting	Likert		Demo. Distri
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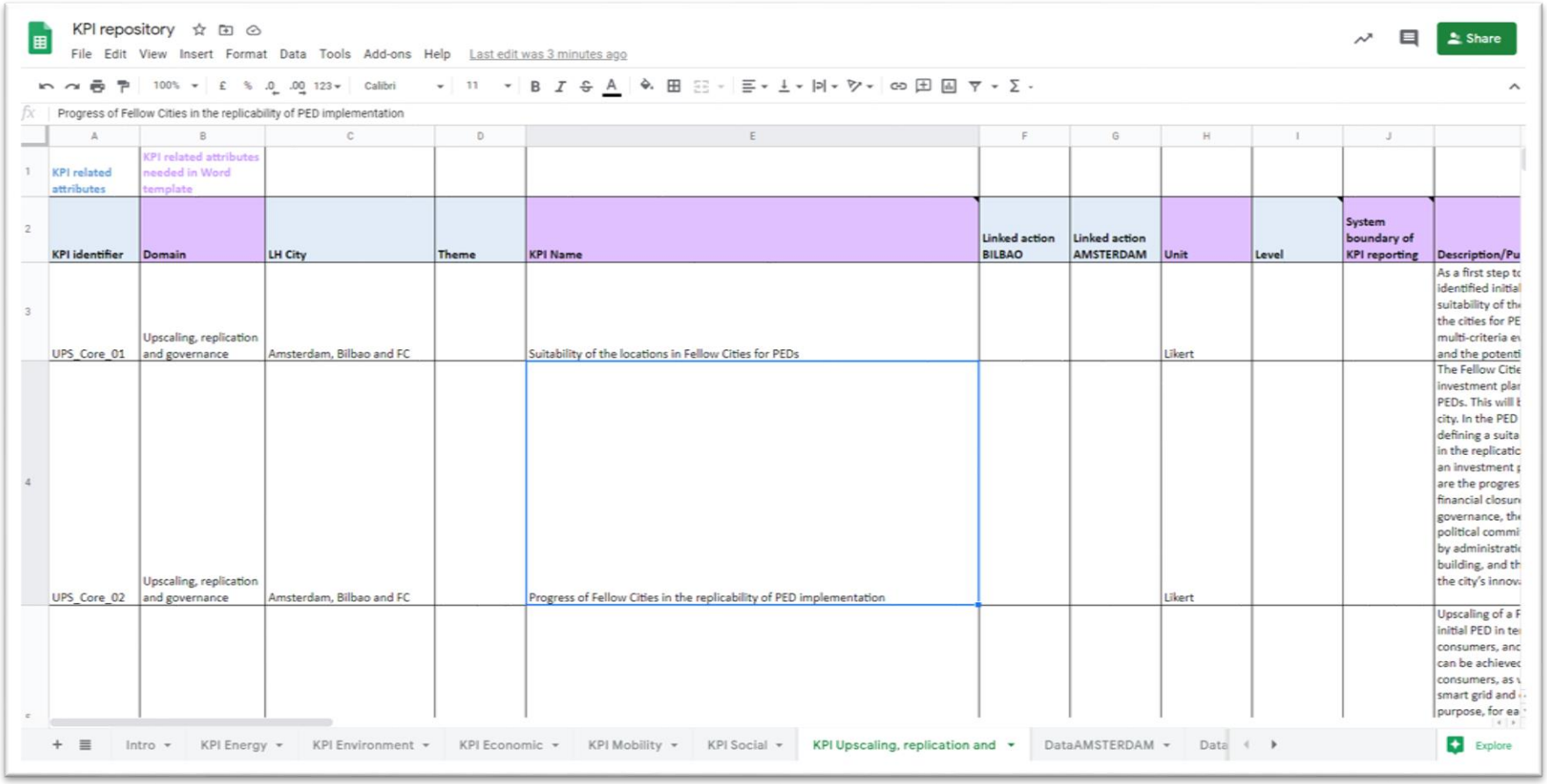

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Progress of Fellow Cities in the replicability of PED implementation

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1	KPI related attributes	KPI related attributes needed in Word template									
2	KPI identifier	Domain	LH City	Theme	KPI Name	Linked action BILBAO	Linked action AMSTERDAM	Unit	Level	System boundary of KPI reporting	Description/Pu
3	UPS_Core_01	Upscaling, replication and governance	Amsterdam, Bilbao and FC		Suitability of the locations in Fellow Cities for PEDs			Likert			As a first step to identified initial suitability of the the cities for PE multi-criteria ev and the potenti
4	UPS_Core_02	Upscaling, replication and governance	Amsterdam, Bilbao and FC		Progress of Fellow Cities in the replicability of PED implementation			Likert			The Fellow Citie investment plar PEDs. This will b city. In the PED defining a suita in the replicatic an investment p are the progres financial closur governance, the political commi by administrati building, and th the city's innov
5											Upscaling of a F initial PED in te consumers, and can be achieved consumers, as v smart grid and purpose, for ea

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Annex 2: KPI TEMPLATE

OCTOBER 2020

Linked to D9.1 (FIRST DRAFT): Repository of definitions of terms, key characteristics archetypes, and a set of KPIs

AmsTErdam BiLbao cItizen drivEn smaRt cities

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KPI template

1. Description			
KPI name		Unit	
Description	*Describes the purpose and motivation for calculating the KPI.*		
Category	*e.g.: energy, environment, social*	SCIS classification	*If applicable, which SCIS document references the proposed calculation of the KPI*
Target	*The expected value/number/unit that each KPI is aiming to achieve.*	Baseline	
Linked Work Package (WP)	WP4	Linked SDG	
2.Methods and calculation			

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Frequency of KPI reporting		Spatial scale of reporting	*Dwelling, building, block, PED, city*
Data requirements	*List of the different data required (name and unit) to calculate the kpi and feed the formula*		
Data capturing spatial level	*Dwelling, building, block, PED, city*	Frequency of data monitoring	*e.g.: continuous, hourly, daily, monthly*
Unit of measurement data	*the unit of measurement at which the data is captured*	Data collection process	*e.g.: data collection spreadsheet, automated collection API.*
Expected availability data		Expected accessibility of data (GDPR)	*if applicable, for example when collected from residents*
KPI calculation formula			
3. Governance Model			
Data provider	*Project partner(s) responsible for the collection of specific data to feed the KPI calculation.*	Performance driver	*Project partner(s) or stakeholder(s) that can influence the performance being monitored by the KPI (e.g. related demo projects).*
KPI owner	*Project partner(s) responsible for the processing of data into KPI.*		

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4. Reference list

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ANNEX 3:

SCIS Monitoring Guides

OCTOBER 2020

Linked to D9.1 (FIRST DRAFT): Repository of definitions of terms, key characteristics archetypes, and a set of KPIs

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SCIS Monitoring Guides: KPIs proposed

SOCIAL MONITORING GUIDE	
Type of KPI	**Name**
Degree of satisfaction/acceptance by inhabitants/tenants/owners	% of addresses/inhabitants/etc. satisfied with the measure
Degree of satisfaction/acceptance by inhabitants/tenants/owners	5 point likert scale degree of acceptance
Level of information & direct participation	% of stakeholders/inhabitants/tenants/etc. Who are satisfied with the level of information on the SCIS activities
Level of information & direct participation	% of stakeholders/inhabitants/tenants/etc. who feel more informed about energy topics after the measures than before
Level of information & direct participation	5 point Likert scale: degree of satisfaction with the level of information on the SCIS measure
Level of information & direct participation	5 point Likert scale: perception on involvement in decision making in the area
Level of information & direct participation	5 point Likert scale: change degree of trust in energy saving methods due to the project
Level of information & direct participation	5 point Likert scale: degree on the increased understanding of energy bills and labels
Active/proactive householders' behaviour	% of householders in the area taking part in a feedback system on their energy consumption or in an energy check
Active/proactive householders' behaviour	% of householders who changed their energy consumption behaviour
Active/proactive householders' behaviour	% of households who measure and analyse their energy use
Active/proactive householders' behaviour	5 point Likert scale: perception on how much the measure changed the behaviour of the householders
Active/proactive householders' behaviour	5 point Likert scale willingness to invest in energy savings measures or to pay more for RES/EE/green electricity
Active/proactive householders' behaviour	% of people who are willing to invest in energy saving measures or to pay more for RES/EE/green electricity
Active/proactive householders' behaviour	% of households who take advantage of ICT devices
Active/proactive householders' behaviour	% of household participating in community renewable energy projects
Internal comfort level and quality of life after the implementation of the project	Perception of owner-occupiers, tenants and employees in demonstration buildings feeling that the internal comfort level (humidity, temperature, natural lighting, noise etc..) has improved because of the project measures
Internal comfort level and quality of life after the implementation of the project	Metered indoor comfort level after SCIS measures

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Internal comfort level and quality of life after the implementation of the project	% of owners, occupiers, tenants and employees in demonstration buildings feeling that the internal comfort level (humidity, temperature, natural lighting, noise etc..) has improved because of the project measures

KPIMG - KPI MONITORING GUIDE	
Type of KPI	**Name**
General technical performance indicators	Energy demand and consumption
General technical performance indicators	Energy savings
General technical performance indicators	Degree of energetic self-supply by RES
General environmental performance indicators	Greenhouse gas emissions
General environmental performance indicators	Primary energy demand and consumption
General environmental performance indicators	Carbon dioxide emission reduction
General economic performance indicators	Total investments
General economic performance indicators	Grants
General economic performance indicators	Total annual costs
General economic performance indicators	Payback period
General economic performance indicators	Return on investments (ROI)
General performance indicators for ICT related technologies	Increased reliability
General performance indicators for ICT related technologies	Increased Power quality and quality of supply
General performance indicators for ICT related technologies	Increased system flexibility for energy players
General performance indicators for ICT related technologies	Reduction of energy price by ICT related technologies
General performance indicators for ICT related technologies	Peak load reduction
General performance indicators for ICT related technologies	Increased hosting capacity for RES, electric vehicles and other new loads
General performance indicators for ICT related technologies	Consumers engagement
General performance indicators for mobility related technologies	Energy consumption data aggregated by sector fuel
General performance indicators for mobility related technologies	Kilometres of high capacity public transport system per 100 000 population

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General performance indicators for mobility related technologies	Passenger-kilometres public transport and private vehicle
General performance indicators for mobility related technologies	Number of e-charging stations deployed in the area
General performance indicators for mobility related technologies	Impact for ICT apps into mobility
General performance indicators for mobility related technologies	Carpooling locations
General performance indicators for mobility related technologies	Clean mobility utilization
General performance indicators for mobility related technologies	Modal split

SRG - SELF REPORTING GUIDE	
Type of KPI	**Name**
Financial data for the renewable energy source	Payback
Financial data for the renewable energy source	Energy related investments
Financial data for the renewable energy source	Total revenues
Financial data for the technology / energy carriers	Total investments costs
Financial data for the technology / energy carriers	Total operating costs
Financial data for the technology / energy carriers	Grants and subsidies
Financial data for the technology / energy carriers	Total energy costs
Financial data for the technology / energy carriers	Dynamic payback period
Technical KPIs for the building	Total final energy demand
Technical KPIs for the building	Final energy demand for Space heating
Technical KPIs for the building	Final energy demand for cooling
Technical KPIs for the building	Final energy demand for electricity
Environmental KPIs for the building	Total GHG emissions
Environmental KPIs for the building	Total primary energy demand
Environmental KPIs for the building	Total share of renewable energies
Economic KPI for the building	Payback
Energy system integration level - Wind energy	Total CO2 emissions
Energy system integration level - Wind energy	Total Primary Energy demand
Energy system integration level - Wind energy	Energy related investments
Energy system integration level - Wind energy	Total revenues

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Mobility and transport level - Technical KPI	Improvment
Mobility and transport level - Technical KPI	Savings (energy consumption)
Mobility and transport level - Environmental KPI	Environmental KPI Savings (%)
Mobility and transport level - Environmental KPI	Economic KPI for the mobility action
Mobility and transport level - Environmental KPI	Mobility related investments
Mobility and transport level - Infrastructure KPI	Energy consumption data aggregated by sector fuel
ICT level	Improvement
ICT level	ICT related investments

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